THE

HUFFORD

STRETCH-WRAP FORMING MACHINE

solves the problem of quick, accurate uniform production of complex shapes from sheets or extrusions

Production runs can be short or long with full economy and duplicate parts are easily re-run at any subsequent date.

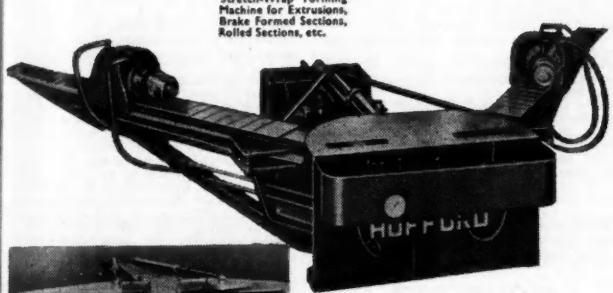
THE HUFFORD STRETCH-WRAP FORMING PRINCIPLE IN 3 QUICK STEPS

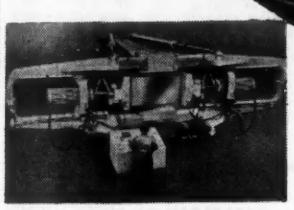
STRETCHED in front of a stationary die, metal becomes semi-plastic.

WRAPPED around die, plasticity aids in moulding metal to die contours.

FORMED at end of wrapping stroke, a final stretch permanently "sets" the shape.

Stretch-Wrap Forming Machine for Extrusions, Brake Formed Sections, Rolled Sections, etc.





Stretch-Wrap Forming Machine for sheet metal work.

Due to the stretching process, metal strength is actually improved. Hufford Stretch-Wrap Forming can be applied to aluminium and many of its alloys, various steels, including stainless, magnesium, etc. The machines, available in stretching capacities from 12 to 350 tons, accurately form both structural parts and sheets for the construction of frame elements and skin surfaces.

Unusual tooling ease is one feature of the Hufford Stretch-Wrap Forming Process. Simple dies, made from easily worked materials are suitable for contouring extrusions and narrow sheets. Steel facing ensures long runs. Dies cast from plaster moulds are most frequently used when forming large sheets.

Now accepted as the world-wide standard of the aircraft industry, Hufford Stretch-Wrap Forming machines are making a valuable contribution to increased productivity in the metal forming industries. If you want to know more about Hufford Stretch-Wrap Forming write to the Wickman Technical Publications Dept., for further details.

WICKMAN LIMITED

FACTORED MACHINE TOOL DIVISION, FLETCHAMSTEAD HIGHWAY, COVENTRY
Telephone: Coventry 60351

265.F.50

THE ENGINEER

ESTABLISHED 1856

Vol. 198 No. 5153

OCTOBER 29, 1954

28, Essex Street, Strand, London, W.C.2.

Telephone : CENtral 6565 Telegrams : Engineer Newspaper, Estrand, London

Published every Friday Registered as a Newspaper

PRINCIPAL CONTENTS

(Complete contents on page 598)

Storm Surges and Flooding in the Thames 598

Some Tests of Electro-Cured Concrete 582
(PROFESSOR A. D. ROSS)

Large Diameter Aluminium Tubes in Structures ... 584
(CEDRIC MARSH)

International Motor Show—No. II 587

Modern Developments in the Use of Large Single Entry Centrifugal Pumps 608
(H. H. ANDERSON)

High-Pressure High-Stroke Diaphragm Mechanism 602
(W. MULLER)

Inanimate Cussedness 599

NOTICE TO READERS

All letters intended for insertion in 'The Engineer or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts: correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

U.K. & ABROAD £5. 10. 0. CANADA £5. 5. 0. annually including postage. Every subscriber is entitled to one FREE copy of the BUYERS GUIDE as published —extra copies 5s. each post free.

CLASSIFIED ADVERTISEMENTS

LINEAGE RATE (Under 1 inch):—2s. 6d. per line of 6 words. Minimum 10s.

INCH RATE (1 inch and over):—Rates per insertion per single column inch— 1 insertion—30s 6 insertions—27s. 6d. 13 insertions—26s. 26 insertions—25s.

USE OF BOX NUMBER: The charge is 2s. including the cost of re-addressing replies, which are forwarded immediately on receipt. N.B. There is no Charge for Box Nos. under "Situations Wanted."

WORDING OF ADVERTISEMENTS: Approximately the firs. 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

INDEX TO ADVERTISERS—PAGE 127

PUBLIC APPOINTMENTS

UNIVERSITY COLLEGE, IBADAN, NIGERIA

RESIDENT ENGINEER

Applications are invited from civil engineers for post of RESIDENT ENGINEER. Graduates with professional qualifications and considerable experience of public engineering preferred. Appointment full time and for three years in first instance. Basic tour 15 months. Salary scale £1500 by £75 to £1800 p.a. Child allowance £50 p.a. per child (max. £150 p.a.) for children resident in Nigeria or £100 p.a. per child for children resident elsewhere (max. £300 p.a.). Passages paid for member of staff and wife and assisted passages for up to three children on appointment, termination and leave. F.S.S.U. Part furnished accommodation at rent not exceeding 7·7 per cent. of salary.—Applications (six copies), naming three referees and stating full qualifications and experience, to be received by 15th November by Secretary, Inter-University Council for Higher Education in the Colonies, 1, Gordon Square, London, W.C.1, from whom further particulars may be obtained. E6231

UNIVERSITY OF LONDON KING'S COLLEGE

RESEARCH STUDENTSHIP

University of London King's College offers a RESEARCH STUDENTSHIP to the value of £350 per annum, tenable for one year with possible renewal for a second year, made available by British Insulated Callender's Cables, Ltd. The Studentship is for research into the mechanical properties of powdered materials in relation to their use as electrical insulators. The character of the research is such that it should lead to a Higher Degree. Applicants should have a good Honours Degree in Engineering or Physics. Particulars and application forms from the Registrar, King's College London, Strand, W.C.2, whom completed forms must reach by November 22nd. E6180

KUMASI COLLEGE OF TECHNOLOGY

LECTURERS

(Principal: W. E. DUNCANSON, Ph.D., D.Sc.)

Applications are invited for the following posts:—
SENIOR LECTURER in CIVIL ENGINEERING.
SENIOR LECTURER in ELECTRICAL ENGINEERING.
LECTURER (Grade A) in ELECTRICAL ENGINEERING (Radio and Telecommunications).
Teaching will be up to Degree standard. Qualifications: Degree and Membership of I.C.E./I.E.E.; industrial and/or teaching experience desirable.
LECTURER (Grade A) in SURVEYING.
To teach land surveying and allied subjects in survey, civil engineering and other courses. Qualifications: A.R.I.C.S. (land survey) and/or appropriate Degree and survey experience.
LECTURER (Grade A) in WORKSHOP PRACTICE.
Qualifications: H.N.C. in Production Engineering, Corporate Membership of I.P.E. and responsible industrial experience.
Now in the early stages of development, the College is autonomous, complementary in function to the University College of the Gold Coast and of comparable status. It has about 800 resident students and plans for up to 2000.
Salary scales:—
Senior Lecturers: £1400–£1850 p.a.
Lecturers (Grade A): £880–£1560 p.a.
Initial salary according to experience. Posts are pensionable but temporary appointments carrying gratuity and 10 per cent. higher salary might be made. Partly furnished houses provided, rent according to salary. Free first-class passages for persons appointed, their wives and up to 3 children under 13. Generous home leave, normally annual, on full salary.
Write for further information to Secretary, Advisory Committee on Colonial Colleges, 1, Gordon Square, London, W.C.1. Closing date for applications (6 copies), 15th November, 1954. E6234

WOOLWICH POLYTECHNIC
LONDON, S.E.18

Principal: J. S. TAIT, Ph.D., B.Sc., A.R.T.C., M.I.E.E., A.M.I.Mech.E.

ASSISTANT, GRADE A

Applications invited for an ASSISTANT, GRADE A, in the Electrical Engineering Department. Post suitable for a person recently graduated; facilities for research; promotion to higher grades within the Department. Salary, Further Education Scale, between £546 and £881, according to qualifications and experience, plus London allowance.
Particulars and application form from Clerk to the Governors, to be returned by 13th November, 1954. E6277

READING TECHNICAL COLLEGE

APPOINTMENT OF MAINTENANCE ENGINEER

Applications are invited from suitably qualified persons for the post of MAINTENANCE ENGINEER at the newly-built Reading Technical College. Salary scale £675 by £30 to £825, with placing according to qualifications and experience. Local Government Superannuation Acts applicable.
Further details and application forms, returnable not later than November 20th, 1954, from the Clerk to the Governors, Education Office, Blagrave Street, Reading. E6194

PUBLIC APPOINTMENTS

ROYAL NAVAL COLLEGE
GREENWICH, LONDON, S.E.10

DEPARTMENT OF CHEMISTRY AND METALLURGY

CIVILIAN LECTURER

Applications are invited for appointment as CIVILIAN LECTURER in the Department of Chemistry and Metallurgy in January, 1955, or as soon after as possible.
2. Applicants must be British subjects and should hold a First or Second Class Honours Degree in Metallurgy or equivalent qualifications, preferably with practical experience.
3. Appointment will be as Lecturer (salary scale £470 by £30 to £680 by £35 to £855) or as Senior Lecturer (£975 by £35 to £1150), according to age, qualifications and experience. In certain circumstances a starting salary above the minimum may be authorised. Advancement to higher posts is possible. Consideration would be given to the secondment for an agreed period of serving members of the Scientific Civil Service.
4. Letters of application, accompanied by names of three referees and a statement of qualifications and previous experience, should be sent as soon as possible to Director of Studies, Royal Naval College, Greenwich, London, S.E.10, from whom further particulars may be obtained.
5. Closing date for applications is 13th November, 1954. E6232

THE FOREIGN OFFICE

COLOMBO PLAN TECHNICAL CO-OPERATION SCHEME

SENIOR LECTURER IN CIVIL ENGINEERING (INCLUDING SURVEYING)

The Foreign Office invite applications under the Colombo Plan Technical Co-operation Scheme for a post as SENIOR LECTURER in CIVIL ENGINEERING (including SURVEYING) at the Engineering College at Rangoon University, Burma. Candidates should have had at least three years' teaching experience at a British university. Those holding higher degrees will be preferred. Salary £1250 p.a. plus a tax-free allowance of £1250 for a married man, £675 if single. Duration one year with likelihood of extension. Contracts between appointees and British Government. Free furnished houses provided in agreeable surroundings with recreation facilities. Children's allowance where appropriate and outfit allowance payable. First class air or sea passages provided.—Further information and application forms from Ministry of Labour and National Service, 26/28, King Street, London, S.W.1. Quote reference A. 12/BE24/54. E6235

THE ROYAL TECHNICAL COLLEGE, GLASGOW

(AFFILIATED TO THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for LECTURESHIP IN ELECTRICAL ENGINEERING on a salary scale of £600 by £50 to £1150; the starting point will depend on qualifications and experience. Applicants should hold a good Honours Degree and the person appointed will be required to lecture on electrical technology to undergraduate students. There are excellent opportunities for participation in post-graduate research. Application forms may be obtained from the Secretary, George Street, Glasgow, C.1. E6217

LONDON COUNTY COUNCIL

CIVIL ENGINEERS, CIVIL ENGINEERING ASSISTANTS AND DRAWING OFFICE STAFF

CIVIL ENGINEERS, CIVIL ENGINEERING ASSISTANTS and DRAWING OFFICE STAFF, for design of large civil engineering works in connection with main drainage and sewage purification. Salaries within range £300–£739. Application form (returnable within 14 days) from Chief Engineer (54/56), London County Council, The County Hall, S.E.1. (S.A.E.) (1338). E6197

GREAT OUSE RIVER BOARD

INTERNAL DRAINAGE DISTRICTS DEPARTMENT

ASSISTANT ENGINEER

Applications are invited for the position of ASSISTANT ENGINEER, to be employed in the Internal Drainage Districts Department on civil engineering design, at a salary within Grade VII-VIII, N.J.C. Conditions of Service, depending upon experience.
Applicants should be University Graduates and/or Corporate Members of the Institution of Civil Engineers.
Application forms and further details may be obtained from the Engineer to the Board, and should be completed and returned to him before 12th November, 1954.

K. M. RODDIS,
Clerk of the Board.

"Elmhurst,"
Brooklands Avenue,
Cambridge. E6265

PUBLIC APPOINTMENTS

CIVIL SERVICE COMMISSION

SENIOR SCIENTIFIC OFFICERS, SCIENTIFIC OFFICERS, PATENT EXAMINER & PATENT OFFICER CLASSES

The Civil Service Commissioners invite applications for pensionable appointments. Applications will be accepted up to 31st December, 1954. Interview Boards will sit at frequent intervals. The Scientific posts cover a wide range of scientific research and development in most of the major fields of fundamental and applied science. In biological subjects the number of vacancies is small; individual vacancies exist at present for candidates who have specialised in palaeobotany, foraminifera, malacology and lichenology. The Patent posts are in the Patent Office (Board of Trade) and Ministry of Supply.
Candidates must have obtained a University Degree with First or Second Class Honours in an appropriate scientific subject (including engineering) or in mathematics, or an equivalent qualification; or for Scientific posts, possess high professional attainments. Candidates for Senior Scientific Officer posts must in addition have had at least three years' post-graduate or other approved experience. Candidates for Scientific Officer and Patent posts who took their degree examination in 1954 may apply before the result is known.
Age limits: Senior Scientific Officers, between 26 and 31, but specially suitable candidates under 26, may be admitted. For Scientific Officers and Patent Classes, between 21 and 28 during 1954 (up to 31 for permanent members of the Experimental Officer Class). Salary (London), Senior Scientific Officers (men), £975–£1150, (women) £845–£1025; Scientific Officers (men), £470–£855, (women) £470–£750; Patent Examiner and Patent Officer classes, (men) £440–£760 (rates under review). Women's rates somewhat lower. Somewhat lower rates in the provinces.
Further particulars from the Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S. 53/54 for Senior Scientific Officers and S. 52/54 S.128/54 for the other posts. E6233

COUNTY BOROUGH OF TYNEMOUTH

WATER DEPARTMENT

APPOINTMENT OF JUNIOR ENGINEERING ASSISTANT

Applications for the above permanent appointment, at a salary within Grades A.P.T. II-IV of the National Salary Scales (at present £520 to £625 per annum), according to qualifications and experience, to assist in the preparation and execution of new schemes of river intake, pumping stations, trunk mains and reservoirs, together with general maintenance work.
Applicants are required to have a University Degree in Civil Engineering or similar qualifications as a Civil Engineer.
Forms of application and conditions of appointment may be obtained from Mr. C. F. J. Lisle, B.Sc., A.M.I.C.E., M.I.W.E., Water Engineer and Manager, 8, Northumberland Square, North Shields, Northumberland, to whom they should be returned by Monday, 22nd November, 1954.

FRED. G. EGNER,
Town Clerk.

14, Northumberland Square,
North Shields,
18th October, 1954. E6174

CITY OF LEICESTER

WATER DEPARTMENT

ASSISTANT CIVIL ENGINEER

ASSISTANT CIVIL ENGINEER required by Water Department of the City of Leicester, to assist in designing and constructing works for water supply, including aqueducts, service reservoirs and the development of a new source of supply. The appointment is a permanent one and the salary is within the range A.P.T. I-V (£490–£670 per annum), depending upon qualifications and length of experience.
Applicants should have passed Sections A and B of the Institution of Civil Engineers' Examination or should hold an exempting Degree. Practical experience, particularly in water supply, is desirable but not essential.
The appointment is subject to the provisions of the Local Government Superannuation Acts, 1937 to 1953, and to a satisfactory medical examination.
Applications, giving full details of training and experience, should be submitted to the undersigned before 20th November, 1954.

HAL WALLHOUSE, A.M.I.C.E., M.I.W.E.
Engineer and Manager.
City of Leicester Water Department,
Bowling Green Street,
Leicester E6200

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

CHIEF COMMERCIAL ENGINEER

The North of Scotland Hydro-Electric Board invite applications for the post of CHIEF COMMERCIAL ENGINEER.
In addition to experience in the electricity industry—not necessarily limited to the field of supply—the special character of the Board's functions makes it desirable that the applicant should have extensive knowledge of general commercial development.
Salary within the range £2500/£3200.
Applications to the General Manager of the North of Scotland Hydro-Electric Board, 16, Rothesay Terrace, Edinburgh, by 15th November, 1954. E6269

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ALDERMASTON, BERKS.

ENGINEERS (BASIC GRADE)

The United Kingdom Atomic Energy Authority, Aldermaston, Berks., requires ENGINEERS (Basic Grade) to take charge of small groups engaged on the following duties.
Post 1 (254/WGE/25).—Development and pilot type production of electronic and other apparatus for physical measurement, with the supervision and testing of small-scale production where necessary. Experience of electronic measuring apparatus, such as oscillography is essential, and a basic knowledge of physics will be required. Experience in either high-speed electronic techniques, magnetic and photographic recording, technical photography, photography and photomultiplier circuits or measuring amplifiers may be advantageous.
Post 2 (255/WGE/25).—Remote control systems for weapon trials. Experience of line and radio communication systems, automatic telephone practice, would be advantageous.
Post 3 (257/WGE/25).—Design of electronic equipment associated with high-speed optical instruments, and to be responsible for the small-scale production of this equipment and its use in trials. Previous experience required in design of circuitry for high voltage short rise time pulses. High-speed tape recording, high-speed counting circuits and ultra high-speed oscilliography experience desirable.
Post 4 (258/WGE/25).—Design, engineering application in field trials of ultra high-speed electronic pulse circuits. Previous experience in field scale trials would be advantageous.
Applicants should have served a recognised engineering apprenticeship or have equivalent experience in a suitable trade, and be Corporate Members of the Institution of Electrical Engineers or have exempting qualifications. Successful candidates will be expected to serve a short period of out-station duty at Fort Halstead, Kent. The salary scale is £620 (at age 25) to £960 (male) per annum. Houses available within a reasonable period for married staff who live outside the Establishment transport facilities. Application form from Staff Recruitment Officer, A.W.R.E., Aldermaston, Berks. Quote appropriate reference numbers. E6

ASSISTANT ENGINEER (MECHANICAL)

OVERSEA GOVERNMENTS AND ADMINISTRATIONS

ASSISTANT ENGINEER (MECHANICAL) required for their London office by the Crown Agents for Oversea Governments and Administrations. Basic salary scale: £650 by £25 to £750, £30 to £960 by £40 to £1000 a year, plus Extra Duty Allowance of approximately 8 per cent. The minimum is linked to entry at age 25 and is subject to increase at the rate of one increment for each year above that age up to 34. Fully qualified officers at least 27 years' old, may be eligible for a special increase of £75 within the scale after two years' service. Engagement will be on unestablished terms with prospect of appointment to the established staff after five years and of promotion. Candidates between 25 and 35 years of age, should have had a sound general education and must either be A.M.I.Mech.E. (preferably in Automobile Division) or have passed the qualifying examination or have an exempting Degree and have served an approved apprenticeship or pupilage with a firm of mechanical or motor service engineers with good subsequent practical experience. The duties of the post will include the preparation of contract specifications, examining and approving drawings and tenders, correspondence and general engineering contract work. Write to the Crown Agents, 4, Millbank, London, S.W.1, stating age, name in block letters, full qualifications and experience, and quote M2A/40501/EH. E6

SOUTH WARWICKSHIRE HOSPITAL GROUP

STRATFORD-ON-AVON HOSPITAL

ENGINEER IN CHARGE

ENGINEER IN CHARGE required for the above hospital. 187 beds plus 77 Part III beds, together with supervision of engineering services at the Monroe Devis Maternity Hospital (22 beds) and South Warwickshire Children's (Recovery) Hospital (40 beds). Salary £900 by £15 (4) by £20 (2) to £1000 per annum). Person appointed will be responsible to Group Engineer for maintenance of engineering equipment and buildings, should hold Ordinary National Certificate in Mechanical Engineering, First Class Certificate, or approved equivalent, have served a recognised engineering apprenticeship, have sound experience in maintenance and operation of steam boiler plant, electrical equipment, heating and hot water supplies and control of staff. Post non-resident.—Applications, with the names of three referees, to Group Secretary, 50, Holly Walk, Leamington Spa, by the 10th November, 1954. E6239

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION

ELECTRICAL ENGINEER

ELECTRICAL ENGINEER required by Electrical Plant Engineering Division of the above Association to carry out applied research in the iron and steel industry. Honours Degree in Electrical Engineering essential. Age range 23–28. Starting salary according to age, qualifications and experience up to £1,000 p.a. Post is superannuated under the F.S.S.U. Location of work London.—Written application only to Personnel Officer, B.I.S.R.A., 11, Park Lane, London, W.1. E6270

THE ENGINEER

OCTOBER 29, 1954

Northam Bridge, Southampton

ON October 20th, a prestressed concrete road bridge, crossing the River Itchen at Southampton, was opened by the Duke of Wellington. The new Northam bridge, as it is called, is built of precast prestressed concrete main beams, of which there are eighty in all, either 85ft or 105ft in length, and weighing up to 50 tons each. The contractor constructed pits of sufficient size to enable the manufacture and curing of two pairs of beams to proceed at the same time. As soon as the beams were sufficiently matured they were moved partly by land and partly by water from the stressing pits to the bridge. Large gantries were constructed over the stressing pits to raise the beams from the pits on to a pair of swivel bogies. Two diesel locomotives were used for the haul to the water's edge, at which point the beams were again lifted by shear legs mounted on a pontoon for transport into their final position in the bridge. By careful planning a maximum production rate of two beams per twelve days from start of manufacture to actual incorporation in the bridge was achieved. The piers and abutments of the bridge, and the flood relief span on the Bitterne approach, with the exception of its decking, which is prestressed, are constructed in ordinary reinforced concrete. All piers rest on a solid foundation on hard ballast. Concrete was placed under water inside the pier cofferdams up to about 5ft below low water mark. At this stage all water was pumped from the cofferdam and further construction proceeded in the dry. The loose ballast around the periphery of each pier was consolidated chemically to a solid mass. A modified landing craft, fitted with concrete mixer, cement containers and aggregate bins, was used to build the piers. The abutments of the bridge and of the flood relief span are carried on piles 40ft long. The approach embankments on both sides are constructed of ballast filling. The bridge has an overall length of 800 yards, including its approaches, but the main structure consists of two spans of 85ft and three spans of 105ft; it has twin 22ft carriageways, two footpaths and a central island, giving an overall width of 66½ft. Its construction was started in April, 1952. The borough engineer and surveyor of Southampton is Mr. F. L. Wooldridge; the consulting engineers were Messrs. Rendel, Palmer and Tritton, and the contractor was Christiani and Nielsen, Ltd.

Natural Gas Developments

LAST Monday, there was a debate in the House of Commons on the National Coal Board's annual report. It was opened by Mr. Geoffrey Lloyd, the Minister of Fuel and Power, who made reference during his speech to recent developments associated with the use of natural gas. He said that natural gas was a "new idea" in this country, but it was advisable to consider it seriously because in recent years it had revolutionised the energy pattern of the U.S.A., where it had provided the energy equivalent to scores of millions of tons of coal. In this country, the Minister continued, the gas industry was searching energetically and hopefully for natural gas, and there was another development of importance. That related to the fact that, at present, billions of cubic feet of natural gas were running to waste in the oilfields of the world. The problem hitherto had been that of transporting this gas to the great consuming areas of the world. The oilfield gas, Mr. Lloyd explained, was methane and, when cooled, it shrank to one-six-hundredth of its former volume and could be obtained at atmospheric pressure. The Americans had developed a new form of cheap refrigerated tanker which depended upon a lining of balsa wood. Advance plans had been made to liquefy the gas near the Gulf of Mexico and to transport it up the Mississippi to Chicago and the other great consuming cities. A good deal of work had been done on the technical factors and on the cost of bringing the liquified gas to this country from either America or the Middle East. Incidentally, the Minister said, in the Middle East alone there was enough natural gas running to waste in the oilfields to take care of half the present total consumption of gas in the United Kingdom. The gas industry, he added, was considering the project and had sent a technical mission to the U.S.A. to study it.

Diesel Engine Users Association

ON Thursday, October 21st, Mr. F. J. Mayor gave his presidential address to the Diesel Engine Users Association on the subject of "Modern Diesel Tugs." Mr. Mayor, who illustrated his address with slides of representative tugs and a short film, remarked that the first cold starting compression ignition diesel-engined tug appeared on the Thames about twenty-five years ago and that since then such tugs had greatly increased in numbers and size. Tugs had a heavy task to perform and an important need was for manœuvrability and for the engine to respond, without fail, to rapid orders from the bridge, orders which called for changes in power, speed and direction under all conditions of loading. This ability to answer controls promptly and accurately, Mr. Mayor said, was an essential characteristic of an engine, even exceeding in importance that of fuel consumption. In connection with this question of response to orders, Mr. Mayor mentioned the trend towards control of the engine directly from the bridge. A tug designed for the handling of ships presented no really difficult problems but, he continued, the barge towing tug had to meet very different conditions which often called for a compromise with regard to propeller diameter which was limited by draught. Turning from technical requirements, the president went on to outline the training undergone by the tug-master to enable him to qualify as a captain of a tug. He pointed out that two years were spent learning the trade, when, following an examination, the apprentice was granted a two-year licence to navigate and load craft and then, continued Mr. Mayor, after further experience and at about the age of twenty-one, the future tug-master had to satisfy the Court of the Watermen's Company as to his competency before being given the Freedom of the River Thames. Having attained his Freedom, the waterman qualified for a Waterman's and Lighterman's Licences, issued by the Port of London Authority.

National Federation of Engineers' Tool Manufacturers

MORE than 200 members and guests attended the annual dinner of the National Federation of Engineers' Tool Manufacturers, which was held in London last week, and the subjects dealt with principally in the speeches, following the dinner, were export and standardisation. The president of the Federation, the Hon. R. A. Balfour, pointed out that the main reason that the direct value of the exports of the firms represented in the Federation was relatively small was because their primary job was to supply manufacturers in the home market with the tools of production. Without a satisfactory supply of such tools the engineering and allied industries could not meet the demands of the export markets. Although tool manufacturers would like to see more of their products exported, home needs came first, and there were also many difficulties and restrictions imposed by overseas countries which could not easily be overcome. On the subject of standardisation Mr. Balfour pointed out that under modern production methods special tools were called for in large quantities, and the demand for many different types presented an obstacle to any appreciable degree of standardisation in the trade. Mr. Peter Thorneycroft, the President of the Board of Trade, said that the work of the tool manufacturing industry was not much publicised, but the industry was doing a good job, and the export market depended a great deal upon its maintaining a good supply of tools to the manufacturing industries. He said that he would like to see more tools exported, and pointed out that the Government helped as much as it could with difficult markets. Competition was growing overseas and there was no trick method of avoiding it; it could only be met by matching quality with quality and price with price.

Armament Research and Development Establishment

AN announcement which has been made this week by the Ministry of Supply says that arrangements have been made for the amalgamation of the Armament Research Establishment and the Armament Design Establishment. The resulting organisation is to be known as the Armament Research and Development Establishment and its headquarters will be at Fort Halstead in Kent. The Ministry describes the present separation of research at Fort Halstead and Woolwich Arsenal from development and design at Fort Halstead as "arbitrary and artificial," as the two establishments have worked closely together for some time. It is expected that the amalgamation will lead to increased efficiency and greater economy. The work of the new establishment will be to further the research, development and design of weapons for the three Services, which are the responsibility, within the Ministry of Supply, of the controller of munitions. Professor Ewen M'Ewen, M.I.Mech.E., has been appointed director of the new establishment at Fort Halstead. Since 1947 he has been Professor of Agricultural Engineering at King's College, in the University of Durham, and has also been Reader in Applied Mathematics since 1952.

International Exchange of Students for Technical Experience

THE International Association for the Exchange of Students for Technical Experience has now published its seventh annual report, which deals in particular with progress during the current year. This year, the report says, the number of effective exchanges made has been 4267, compared with 3783 last year, and 920 in 1948, which was the first full year of the Association's operations. There are now nineteen member-countries of the Association, a total that is likely soon to be increased to twenty-one as India and Turkey have applied for admission. It is interesting to note from the report the "industrial distribution" of the students received this year by the various countries participating in the exchange scheme. There were fifty-four students accommodated in the aircraft industries, 242 in chemical engineering, 472 in civil engineering, 674 in electrical engineering, 1034 in mechanical engineering, 201 in metallurgy, 304 in mining, 90 in naval engineering and shipbuilding, 48 in oil technology, and 57 in textile engineering. Of the total number of students taking part in the exchanges this year, Great Britain sent 564 abroad and received 671 from other countries. The biggest participant in the scheme was Germany, which sent 950 students and received 924 from other member-countries. A general comment made in the report is that in the past some member countries have not emphasised sufficiently to the students nominated to go abroad the necessity of fulfilling their obligations in detail to the industries which have offered to receive them and to the lodgings arranged for them.

Some Tests of Electro-Cured Concrete

By PROFESSOR A. D. ROSS, M.I.C.E.

A brief résumé of the effects brought about by electro-curing concrete is given here, as an introduction to an account of a series of tests carried out on electro-cured concrete cubes. The author considers that the importance of this technique may well lie in providing an accelerated strength test ; this aspect of the tests is commented upon, and the variation of the electrical resistance of concrete is also discussed.

BY passing an alternating electric current through freshly placed concrete its temperature can be raised and this phenomenon has been exploited to protect concrete from frost. In Sweden and in Russia concrete has been treated in this way on a considerable scale from 1932 onwards, and more recently Itakura[1] has described the use of electro-curing in some eighty structures in the post-war reconstruction of Japan. There is also at least one recorded[2] application of the method to obtain high early strength in a precast product.

Ideally, a prism of concrete should be cured between plate electrodes which completely cover two opposite faces. The generation of heat is then uniform throughout the mass and the resulting temperature distribution is uniform except for the effects of heat losses from the boundaries. Theoretically, this uniformity in the generation of heat is superior to the conditions in steam curing, which may cause severe temperature-space gradients when the boundary temperature is raised rapidly. It is not generally practicable, however, to use two opposed electrodes to serve the whole of a concrete member, and various practical expedients have been developed. For example, intermittent plates may be used on opposite faces of a beam or slab, thus avoiding excessive sizes and inconvenient shapes for the electrodes. In the case of road slabs with only one exposed face, strips laid on this surface can be alternately connected to opposite poles of the supply. In this case the heating effect is by no means uniform, since the current tends to follow the shortest path between the electrodes, viz. the path near the surface. Under the conditions of electro-curing, however, the electrical resistance of concrete increases markedly after a critical period, and this effect deflects the path of the current deeper into the uncured parts of the slab so that most of the mass experiences the heating effect.

Other methods for applying electro-curing utilise steel bars or nets embedded in the concrete. In the case of walls, special rods can be passed through the shuttering. They are alternately connected to the poles of the supply and, having no other function than to serve as electrodes, the ends are subsequently cut off flush with the surface when curing is complete. In the case of piles and columns, the longitudinal reinforcement with its associated transverse steel can serve as one electrode while an isolated central bar is connected to the other pole of the supply. Wire nets, which are relatively cheap and can be placed in vertical or horizontal planes, have also been used as electrodes. In all these cases the heating effect is, of course, not uniform because the density of the current varies from point to point in the concrete and, in the literature, there is much reference to suitable voltages and spacing of electrodes to obtain a satisfactory overall result. An alternative method utilises the steel reinforcement as the heating element ; electrical energy is transformed, in the steel, to heat, which then moves by thermal conduction into the surrounding concrete. But there is some evidence that a high temperature differential between the steel and concrete may lead to a reduced bond strength, and, as far as the author is aware, no great success has been claimed for this method.

The data concerning the energy required and the cost of electro-curing are extremely variable. The energy for a complete treatment appears to range from 15kWh to 150kWh per cubic yard and the cost has been quoted variously between 7 and 30 per cent of the concrete price. These data are not necessarily conflicting because there are many factors which greatly influence the energy required. The maximum temperature required above the ambient is obviously an important variable. The maintenance of a modest few degrees above freezing point will require a much smaller power than, say, a temperature in the range 50 deg. to 90 deg. Cent. when the heat losses assume great importance. The size and shape of the member, the thermal insulation, the period of curing, the specific heat of the concrete, and the contribution made by its own heat of hydration are all factors contributing to the variability of the quoted figures.

Electro-curing has generally been applied as a protective measure and there is little evidence of much attention to its effect on strength except in a qualitative manner. McIntosh[3] was the first in this country to make a systematic study, not only of the temperature-time and resistance-time relationships, but also of the strength of the treated concrete. He showed that, by electro-curing, a strength of over 3000 lb per square inch could be obtained in twenty-four hours from a normal concrete even when cast in a cold storage chamber. He also demonstrated a relationship between the strength-maturity characteristics of normally and electro-cured concrete, although this was confined to rather low maturities and the effects on long-term strength were not examined.

It is doubtful whether electro-curing would be economically justified for in-situ work in the relatively mild climate of this country, but it might be worth while for precast products demanding a high early strength. There is also the possibility that it might provide a means of accelerating the growth of maturity so that long-term strength could be predicted after a few hours. An accelerated strength test is greatly needed and for it electro-curing appears theoretically to have a marked superiority over steam curing because of the uniform generation of heat throughout the specimen.

Thus the strength of electro-cured concrete is of interest and perhaps of importance. The other fundamental quantity which merits examination is the electrical resistance of concrete and its variation with time. The actual temperature reached in practice is greatly influenced by many factors, but we cannot even start to estimate the probable effect of applying a potential unless we have some knowledge of the resistance of the concrete on which the heating effect depends. This article briefly describes a series of tests on 225 cubes which was designed to throw additional light on these two matters.

Apparatus Used for the Tests

In some preliminary tests, 3in cubes were cured between electrodes of 16 gauge copper in moulds of hardwood. Following McIntosh, provision was made for a shallow pool of water to be maintained over the exposed surface during curing to avoid drying out. Electro-curing of practical structures for protection against frost does not present this problem because of the moderate temperatures employed, but it assumes importance in accelerated curing at temperatures approaching 100 deg. Cent.

In the main series of tests, 6in cubes were used and drying out was prevented by covering the exposed face of the concrete by a rubber membrane which was pressed down firmly on the four edges of the mould, thus forming a seal. This proved to be very effective in preventing the loss of moisture and it was both more convenient and more reliable than the use of surface water. Repeated curing of wet concrete at elevated temperatures proved too arduous for the wooden moulds which began to warp and crack. Latterly, the concrete was treated in steel moulds lined with ¼in phenolic plastic sheet which has a high electrical resistance, good dimensional stability and a low water absorption. These moulds proved very satisfactory and remained in good condition after prolonged use. Temperatures were recorded generally by mercury in glass thermometers and, in a few cases, by copper-constantan thermo-couples connected to a suitable indicator.

The electrical circuit is shown in Fig. 1.

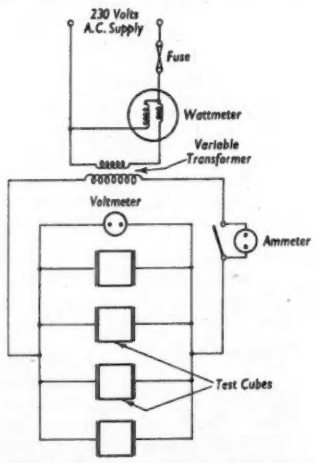


Fig. 1—The electrical circuit for curing concrete cubes

It provided for the simultaneous curing of four cubes under a potential which could be altered at will by a variable transformer. Provision was also made for measuring the voltage, the current and the total energy consumed. In some of the later tests a minor alteration to the circuit was made to permit the measurement of the current passing through each cube ; this enabled the variation of the resistance of each individual specimen to be studied.

Preliminary Tests

Preliminary tests were conducted with 3in cubes of 1 : 2 : 4 vibrated concrete using normal Portland cement, a maximum aggregate size of ⅜in and a W/C ratio of 0·5.

Curing at constant voltages for twenty-six hours gave the temperature-time records shown in Fig. 2. In each case the fall in temperature after reaching the maximum occurred shortly after the resistance, having reached a minimum, started to increase again. These changes will be referred to later, but it is noticeable that prolonged treatment becomes less and less effective due to this phenomenon. The strength of concrete is a function of its maturity, which is defined as the integral of time and temperature (from a datum of −10 deg. Cent.),

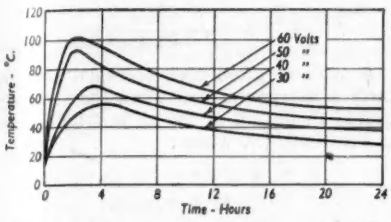


Fig. 2—Time-temperature records of 3in cubes

and, for the records shown in Fig. 2, the gain of maturity due to electro-curing amounts approximately to 1040 deg., 890 deg., 630 deg. and 430 deg. Cent.-hours for 60V, 50V, 40V and 30V respectively.

Having obtained some knowledge of the temperatures and maturities to be obtained with these voltages, a series of tests was conducted to compare the strengths of electro-cured and normally cured specimens. Cubes were cured under 60V, 50V, 40V and 30V for approximately twenty-four hours, and a pool of surface water was maintained throughout. After electro-curing, the cubes were allowed to mature at an average room temperature of 17·5 deg. Cent. Meanwhile, the control cubes for normal curing were maintained wet for one day and thereafter stored beside the electro-cured specimens until tested. The strengths of thirty-eight cubes are presented in Fig. 3 on the basis of

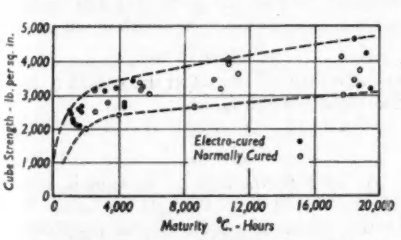


Fig. 3—Preliminary tests of strength of 3in cubes. W/C ratio 0·5

maturity calculated on a datum of −10 deg. Cent. This diagram shows the scatter usually associated with crushing tests of cubes and it suggests that electro-cured and normally cured concretes have approximately the same strength at the same maturity. The strength-maturity relationship is, of course, inadequately defined, but there was some suggestion in the individual results that the long-term strength at about 18,000 deg. Cent.-hours was impaired by increasing the curing voltage and, therefore, the temperature and the rate of heating. The lowest voltage gave the highest strength and vice versa, but there were insufficient results to establish any conclusion.

These preliminary tests served their purpose in establishing certain basic data, but the need to maintain a layer of surface water was unsatisfactory experimentally. Unless the supply of water was regulated very precisely the cube either suffered from drying or from cooling due to an excess flow. It was obvious also that the apparent resistance of the specimen and the energy consumed were greatly affected by the surface water. This method was therefore abandoned and subsequent efforts were devoted to the new technique using a rubber membrane.

The Main Series of Tests

The 6in moulds used in these tests permitted the use of ¾in aggregate in the 1 : 6 mix and a W/C ratio of 0·45 was adopted. A waiting time of thirty minutes (dictated by practical considerations) was followed by a six-hour period of electro-curing under a potential of 60V, 65V or 70V. This relatively short treatment, nevertheless, ensured a reasonable gain in maturity of the order of 600 deg. Cent.-hours because of the slower cooling of these larger cubes after switching off. Furthermore, the increasing resistance (see Fig. 4) makes continued treatment relatively less effective, and after six hours the temperature in all cubes was decreasing. In this series, 140 cubes were tested, half of these being controls which were normally cured. All cubes, except while actually undergoing electro-curing, were matured in a curing chamber at a constant temperature of 17 deg. Cent. and a high relative humidity in the range 90 to 100 per cent.

Electrical Resistance of Concrete.—The results of resistance measurements are too numerous for presentation in full, and Fig. 4 shows a typical record for a 6in cube cured under 70V. The discontinuity in the resistance-time curve at about two and a half hours is a manifestation of the phenomena associated with setting as discussed by Calleja.[4] Thereafter, the resistance increases and so the heating effect is reduced. Increasing losses of heat at the surface combined with a reduction in the internal generation of heat is reflected, after a time lag, in a reducing temperature after the attainment of a maximum.

The form of resistance-time curve shown in Fig. 4 was repeated many times with some variations in the numerical values. For example, the minimum values of specific resistance ranged from 210 to 370 ohms per cubic inch. The minimum was reached generally after about two and a half hours, exceptionally as early as one and a quarter hours, and never later than three hours. After six hours the specific resistance had risen to values in the range 425 to 700 ohms per cubic inch. It was thought at first that the resistance might be very sensitive to variations in the composition of the concrete and particularly in the water content, but a few ancillary tests seemed to disprove this. The resistance of 1 : 1½ : 3 and 1 : 2 : 4 concretes with W/C ratios varying from 0·4 to 0·65 did not vary much and fell generally within the range outlined above. With a 1 : 3 : 6 mix and a W/C ratio of 0·5 the resistance was distinctly higher, having a minimum value of 420 ohms per cubic inch. The same mix with a W/C ratio of 0·4 showed a very large resistance varying from 1430 to 1590 ohms per cubic inch.

Thus the resistance-time relationship shown in Fig. 4 may be assumed to be characteristic of most practical concretes excluding very lean dry mixes. It should, however, be emphasised that this characteristic can be expected only if the temperature régime is similar to that in these tests, since the resistance-time relationship is closely linked with the temperature-time function.

Strength of Electro-Cured Cubes.—Both electro and normally cured specimens were tested in compression over a range of maturities up to 18,000 deg. Cent.-hours, which is approximately equivalent to twenty-eight days at 17 deg. Cent. reckoning from a datum of −10 deg. Cent. Fig. 5 shows the results of 140 tests, each plotted point representing four cubes.

This diagram presents a somewhat similar picture to that of Fig. 3, but with augmented strengths because of the lower W/C ratio. Fig. 5, however, reveals that at low maturities up to about 2000 deg. Cent.-hours the electro-cured specimens are definitely stronger than normally cured specimens of the same maturity. This agrees with the results presented by Saul,[5] who suggests that this

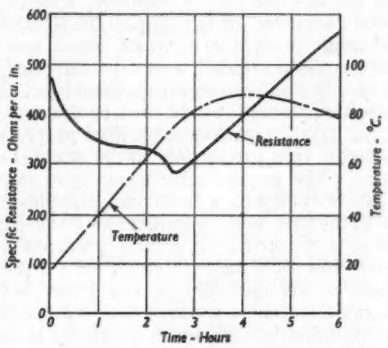


Fig. 4—Typical record of variation of temperature and specific resistance in a 6in cube, under 70V

disproportionate gain in strength may be due to the tricalcium aluminate which makes a special contribution to early strength when concrete is subjected to elevated temperatures in the first hours of its life. Another way of putting this is to say that strength is not a simple function of the integral of time and temperature, but is related in a more complicated manner to these variables. Fig. 5 includes one result at 9000 deg. Cent.-hours with a strength so much higher than the general trend (due to some undiscovered cause) that this point has been excluded from the envelope. Even disregarding this point the results suggest that the electro-cured cubes are somewhat inferior in strength to the normally cured specimens after about 4000 deg. Cent.-hours, equivalent to nine

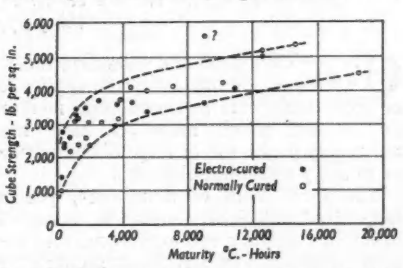


Fig. 5—Strength of 6in cubes. W/C ratio 0·45. Each point represents four cubes

days of normal temperature. Saul has noticed the same effect with steam curing when the temperature gradient was too high. In the present tests the gradients were generally between 0·33 deg. and 0·5 deg. Cent. per minute, which is fairly rapid, and this appears to have had an adverse effect, although not a very serious one, on the long-term strength. It is possible that rapid electrical heating may be less injurious to long-term strength than rapid steam heating because of the uniform temperature distribution within the cube.

Conclusion

These tests confirm that high early strength can be obtained by electro-curing. There is no evidence that this treatment has any peculiarly beneficial effect other than by heat curing and the results obtained are comparable to those for steam curing.

In the search for an accelerated strength

test, however, the electrical method would appear to have distinct advantages. There can be few constructional sites without an electrical supply, and it is obviously simpler to "switch on" than to control the rise in temperature in a steam chamber. Furthermore, the temperature distribution in electro-curing is nearly uniform in contrast to the severe temperature-space gradient in steam curing. The tests have shown that an impermeable membrane can readily be used to prevent the loss of moisture, which is a vital condition. It is thus possible to outline a simple procedure in which cubes, cast in standardised moulds, would be subjected to a specified potential for a specified time. The resulting strength would then be the twenty-eight days' strength or some fixed proportion thereof, this proportion to be decided by tests. The present experiments have shown that, for one mix, a fixed voltage applied for a fixed time gives approximately the same gain in maturity. If greater precision and provision for a range of mixes were required then a voltage control could be incorporated so that a specified time-temperature relationship was obtained accurately in each cube.

It would be wrong, however, to be too sanguine about the success of such a test, because of the fundamental difficulty of the different contributions to strength made by the various constituents in cement. Some compounds (e.g. tricalcium aluminate) respond strongly to an early elevated temperature while others make their contribution much later and thus strength is not simply related to maturity. Therefore it seems unlikely that there could be one universal standard of acceleration of maturity for the prediction of long-term strength with all classes of cement, since the constitution varies so widely. This difficulty would apply, of course, to any such test and not merely an electric one.

It is, however, quite possible that different régimes of heat curing might be found to give consistent results for the different classes of cements and the physical chemistry of cements might give some clues as to suitable treatments. An extended programme of tests under rigorous control would be required to establish the necessary data on a reliable statistical basis. The experiments described here do not provide these data, but they do show that electro-curing is a most convenient method of providing the gain in maturity which could readily be developed on simple practical lines.

The author is indebted to his former students, Messrs. R. B. Sims, M. C. Roberts and M. A. F. Rush, for the experimental data which were obtained in the concrete laboratory of King's College, London.

REFERENCES

[1] C. Itakura: "Electric Heating of Concrete in Winter Construction," *Journal Am. Conc. Inst.*, 23 (5) 753-67, 1952.
[2] Anon.: "Concrete Products Cured Electrically," Rock Products 40 (4), 94-95, 1937.
[3] J. D. McIntosh: "Electrical Curing of Concrete," *Mag. of Conc. Res.*, No. 1, 21-28, 1949.
[4] J. Calleja: "New Techniques in the Study of Setting and Hardening of Hydraulic Materials," *Journal Am. Conc. Inst.*, 23 (3) 525-36, 1952.
[5] A. G. A. Saul: "Steam Curing and its Effect upon Mix Design," Symposium on Mix Design and Quality Control, C. and C.A., 1954.
Further references to works on electro-curing can be found in Building Research Station Library Bibliography No. 77

Large Diameter Aluminium Tubes in Structures

By CEDRIC MARSH

A certain amount of work has been done on the use in structures of large diameter aluminium tubes formed from sheet. This use of aluminium sheet as a structural medium is studied and the economic and design reasoning for its application to this purpose is examined.

ON the Continent and elsewhere there is an increasing interest in the application of sheet aluminium as a structural medium, an interest which manifests itself most noticeably in the use of large diameter tubes as primary structural elements.

The sheet form of aluminium, particularly the mill-finish sheet, is somewhat lower in cost than are extrusions, and even after forming into structural sections, the price difference is often still evident, so that there is an immediate advantage in the use of sheet even if no further benefits could be gained.

In order to obtain the maximum structural efficiency, it is necessary to employ sections having a high ratio of overall dimension to wall thickness and, in contrast with extrusions, formed sheet can achieve this, virtually without limitation, without influencing the cost of material. Further, overall cross-sectional dimensions are only limited by the width of sheet available and even this can be overcome by joining sheets longitudinally.

As stretcher levelled sheet is unnecessary, roller levelling being quite acceptable, the length of section is limited only by the available press-brakes or roll formers. This limitation is normally 10ft to 15ft, but with larger equipment tubes of 30ft in length can be produced without any transverse jointing. With members of this size available it is possible to design relatively heavy structures without any real problem.

To obtain from a given area of metal the maximum carrying capacity, either in bending or as a strut, it is necessary to spread the walls to such an extent that local elastic instability of the walls themselves provides the design criterion. Because of this the influence of the elastic modulus, which is sensibly constant for all aluminium alloys, is as important as strength, and little or no advantage can be gained by the use of expensive high strength alloys; thus, not only is aluminium employed in its cheapest form, but also the cheaper, medium strength, alloys can be utilised. A further advantage of this is that the more corrosion resistant, cold worked alloys are adopted, with some benefit to the finished structure.

Because of the low stresses, welding, particularly in a longitudinal direction, becomes as acceptable as it is desirable, resulting in cleaner and lighter structural elements than can be obtained by riveting.

Some disadvantage may arise in the use of thin walls at joints where there is the problem of getting load in and out of a member. Bearing of rivets or bolts in the walls may necessitate a relatively large number of fixings in order to generate the required strength, but so far this problem has not proved to be insurmountable nor has the solution been such as to detract from the overall advantages of the construction.

DESIGN

Struts.—The most common method of establishing the critical stress for local failure of a thin wall is by the concept of equivalent slenderness ratios. Broadly, the idea is that if the critical stress of a thin wall is equal to the critical stress of a strut of known slenderness ratio, the equivalent slenderness ratio of the wall is equal to that of the strut.

The slenderness ratio of a strut is:

$$\frac{l}{k}=\frac{\text{length}}{\text{radius of gyration}}.$$

For a tube formed from sheet subject to direct axial compression, the equivalent slenderness ratio of the walls is

$$5{\cdot}7\sqrt{\frac{R}{t}}=5{\cdot}7\sqrt{\frac{\text{radius}}{\text{thickness}}}.$$

A strut of given cross-sectional area will carry a maximum load when the strut fails overall in flexure at the same critical stress as the walls, i.e. when:

$$\frac{l}{k}=5{\cdot}7\sqrt{\frac{R}{t}}$$

k for a tube $=R/\sqrt{2}$, therefore,

$$l^2=16\frac{R^3}{t}.$$

With this relationship a cylindrical tubular strut of uniform wall thickness is most efficient.

In order to obtain a maximum load carrying capacity for a strut of given length and with a given volume of material, it may be desirable to vary both diameter and thickness along the length. A variation in thickness, however, is neither practicable nor theoretically desirable (unless it is a thickening at the ends to reduce the end diameter to facilitate fixing) and, as intermediate joints other than that at the centre are rarely necessary in practice, the most efficient tubular strut, all aspects considered, would appear to be one of a uniform thickness tapering in diameter uniformly from the centre to the ends.

The critical load for a non-uniform tube depends on the law governing the variation of the moment of inertia, which in our case is:

$$I_x=I_0(1+ax)^3$$

and the ratio of inertia at the centre I_c to the inertia at the end I_0, i.e.:

$$\frac{I_c}{I_0}=\left(\frac{R_c}{R_0}\right)^3.$$

At the ends the area of the tube is dictated by the direct load it must sustain. Now, in the range of purely elastic instability of the walls, the critical stress is proportional to t/R and, as the axial load is constant and the thickness uniform, the applied stress will be inversely proportional to the diameter, thus, the ratio of critical stress to applied stress is constant throughout the length of the column. However, as the R/t ratio is reduced, the local buckling stress falls below that yielded by purely elastic considerations, owing to plasticity of the material, thus it will be the end dimensions which are of first importance in establishing the local stability, the remainder of the tube automatically having a higher factor of safety against this mode of collapse. It follows that excessive reduction of the end diameter cannot lead to greater efficiency.

The critical load for a simple double-tapered tube of uniform thickness is given by:

$$P_{cr}=\frac{nEI_0}{l^2}$$

where n depends on the ratio of the end and centre radii and is given approximately by:

$$n=c^2(c+9) \text{ where } c=\frac{R_c}{R_0}$$

for values of R_c/R_0 up to a maximum of 2.

The equivalent slenderness ratio of the tube is thus :

$$\frac{\pi}{\sqrt{n}}\frac{l}{R/\sqrt{2}}.$$

In the normal range of struts where local and overall instability govern equally, it is not possible to effect any saving in the weight of a tubular strut of uniform thickness by adopting a tapered form, owing to the end dimensions dictating the failing load. However, where because of some practical considerations, relatively thick sheet is used, and local instability does not govern, then some economies may be achieved by the use of non-uniform tubes.

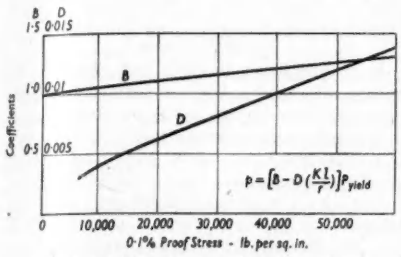


Fig. 1—Coefficients in straight line column formulæ (from Alcoa)

Certain assembly methods for tubular members require a tapered form in which case it becomes necessary to apply the above formulæ.

Beams.—Although tubes do not, theoretically, provide good beam sections, where bending can take place in any direction they are as suitable a form as any, and, even where bending is confined to one plane only, the facility of fabrication can in certain instance justify their use.

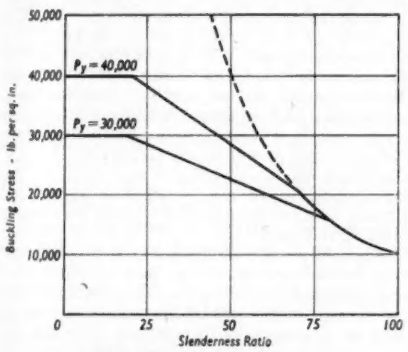


Fig. 2—Typical strut curves

Where stress is the governing consideration, the maximum moment of resistance of a tube is given by :—

$$\pi R^2 tf$$

where f is the buckling stress of the walls.

The critical stress of the tubes when subjected to bending may be as much as 25 per cent higher than when subjected to direct load but because such forms of buckling cannot normally be predicted with great accuracy, and to standardise the formulæ, this possible benefit is neglected.

By adopting a simple straight line formula for the buckling of struts, the critical stress for the wall in the medium range of slenderness is given by :—

$$f=\left(B-D\,.\,5{\cdot}7\sqrt{\frac{R}{t}}\right)p_y$$

where B and D are empirical constants depending upon the proof stress of the alloy and are given in Fig. 1. (Fig. 2 gives some typical strut curves.)

It can readily be shown that for a given area of cross section, the tube providing the greatest bending resistance is one in which the equivalent slenderness ratio of the walls is :

$$5{\cdot}7\sqrt{\frac{R}{t}}=\frac{B}{2D}$$

which, for an alloy with a 0·1 per cent proof stress of 30,000 lb per square inch, is approximately equal to 70.

Should the value obtained fall outside the range of validity of the straight line formula, then the required point is where the straight line meets the Euler curve.

In relatively small tubular towers in which the thickness is uniform, it is rarely possible even by tapering the tube, to realise this ideal, while stressing the tower to the maximum allowable, at more than one point. It is usually most desirable for this point to be at the base, when stress is the design criterion, even though the true maximum stress may not actually occur here.

Should deflection be the governing factor, the ratio of radius to thickness might be increased until the critical stress for the walls governs simultaneously. However, should the diameter of the tube be limited, then maximum rigidity for a given volume of material is most simply obtained by arranging the taper and the thickness so that ratio of applied stress to critical stress is sensibly uniform. This does not yield the absolute minimum of material for a given deflection, but because of the varying factors of loading, degree of taper and practical limitations, no mathematical exactitude is possible in the analysis, and the above approach is quite suitable for adoption in practice.

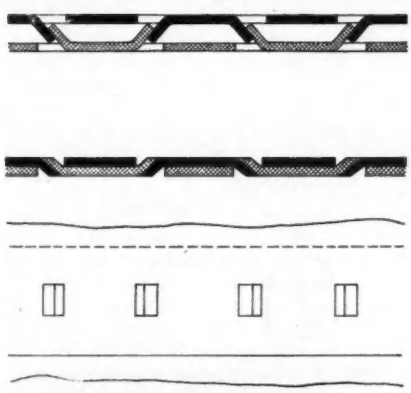


Fig. 3—Riegelnaht interlocking seam

In order to gain additional strength in bending from a tube, it is sometimes converted to an ellipse. A circular section of diameter D can become of maximum strength when converted to an ellipse with a ratio of major to minor diameter equal to 3. The section modulus is thereby increased from $\frac{1}{4}\pi D^2 t$ for the circle to $9/32\pi D^2 t$ for the ellipse. A further increase in strength can be attributed to the increased curvature of the walls at ends of the major diameter where the stress is highest. However, the increase in strength rarely justifies the added difficulty of fabrication and such tubes are seldom employed for other than æsthetic reasons.

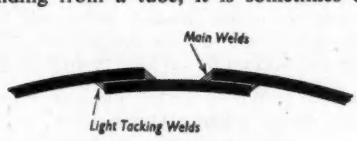


Fig. 4—Longitudinal weld

Fabrication

To form a tube from sheet the first operation is the curving of the sheet by a three-roll former or by pressing. By adjusting the inclination of the central roller it is possible to impart any required taper to the tube. Pressing is normally only used for parallel tubes but has the advantage that longer components can be made.

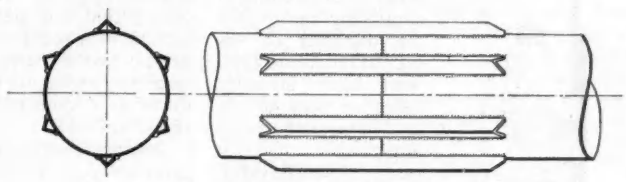


Fig. 5—Longitudinal splicing ribs

The separate component sheets, a minimum of one if roll formed and two if pressed, can be joined longitudinally to form a tube by riveting, welding or by the patented interlocking seam called " Riegelnaht." Riveting is both more difficult and more expensive than either of the other two methods and is not often applied.

The " Riegelnaht " seam is made by punching the sheet, as in Fig. 3, feeding the tongues in the appropriate holes and hammering or pressing to provide the final fixing. This joint has no great strength in resisting tension but provides a highly satisfactory and cheap means of longitudinal fastening when only longitudinal stresses are to be carried. Should any forces tending to burst the tube arise, reinforcing rings are desirable.

Longitudinal welds are usually of the butt type or, in more recent designs, of the kind shown in Fig. 4, as by using this form the need for very accurate forming of the tubes is eliminated. Because of the problems associated with distortion it has been found that the inert metal arc (consumable electrode) method of welding is by far the most suitable, but normal argon arc equipment has been successfully employed.

Because there is no transfer of direct load through longitudinal joints, they do not provide any real structural problem, but in the case of transverse connections between tubular segments the full load must be transmitted. Welding affects the strength of the entire cross-section and cannot normally be used on site, but where stresses are low and shop welding is possible this method has been employed. If full structural welds are required for transverse jointing then after making the circumferential weld between the tubes the majority of the loss of strength can be made good by adding longitudinal splicing ribs, as in Fig. 5. In very large diameter tubes these ribs can be fixed inside to maintain the external appearance.

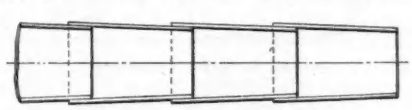


Fig. 6—Longitudinal joints

The "Riegelnaht" is unsuitable for this type of connection. There are two normal techniques. Either the tubes are riveted or bolted together using an intermediate butt

strap of a flat or " T " section or angle rings, or tapered tubes are forced one into the other by a load sufficient to ensure considerable circumferential stressing of the tubes.

In this latter technique it is necessary to reinforce the ends of the outer tubes and, in order to generate the full strength of the member in bending, the overlap of the tubes must be equal to something more than the diameter of the tube at the connection. With larger diameter tubes the material lost at the overlap becomes appreciable so the technique can be taken a step further and the tapered tubes inserted one in the other as in Fig. 6, such that the minimum thickness is at least double that of the individual tube. The percentage loss due to overlaps can be made smaller and tests have shown that, because of the effective prestressing of the tubes, the actual carrying capacity is greater than would be realised by a single sheet of the same overall thickness.

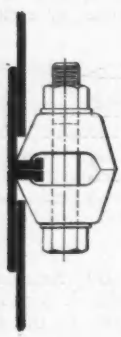


Fig. 7—Jointing clamp

This means of joining tubes can only be used by members subjected to bending or compression, the tensile strength being equal, roughly, to the force employed to make the joint.

The greatest advantage of the method is the facility and speed with which assembly can be carried out on site as the entire member, composed of a number of segments, can be assembled in one operation while the individual tapered units nest compactly for transport.

When this technique is not suitable, site jointing of the separate units has, so far, been by bolting or riveting, the actual type of connection depends on the diameter of the tube and the accessibility of the inside surface. Where there is room for an operator inside the tube, a " T "-ring butt strap is the most desirable as the load is transmitted through the bolts in shear and the straps provide a stiffening ring for the tube. When the tube is too small for access and the operator can only work on the outside, butt straps can still be used if some method of blind bolting or riveting is adopted, but the simplest joint is by angle rings riveted to the ends of the tubes which are joined together by direct bolting to form an external flange. The greatest drawback to this joint, however, is that, when the fixing is in tension, there is considerable eccentricity of the joint causing an abrupt disturbance of the stress flow. One solution is the use of clamps, Fig. 7, which reduce to a minimum the eccentricity of the fixing.

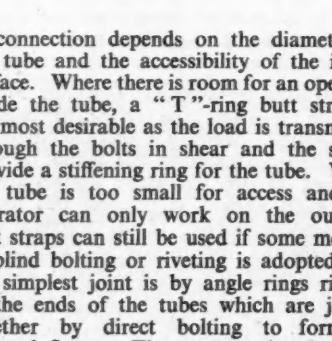


Fig. 8—Gusset connections

Perhaps the most difficult joint to provide when large diameter tubes are used is that at the node point of a latticed frame, particularly when two planes of bracing meet at the same point on the corner member of a tower structure. One proposed solution to this problem effected the joint by distorting the ends of the tubes from the circular to a triangular or square form, thereby forming common planes to which gussets could be applied (Fig. 8). However, experience has shown that any deformation of a circular section with relatively thin walls results in a drastic loss of strength in any but tension members owing to the local bending introduced as a result of the local deviation from the ideal form.

Another method (Fig. 9) uses a welded junction piece which obtains the necessary strength of fixing to the tubes by means of longitudinal welds. Such welds influence a minimum amount of the cross sectional area. From the aspect of joint efficiency, this connection is superior to most other methods and will probably become the standard way of making this type of joint. However, to make it successfully, the inert metal arc method of welding is virtually indispensable owing to the relatively large difference in the thicknesses of metal to be joined. Using other, slower welding methods it is difficult to control distortion and a much larger area of the tube becomes annealed.

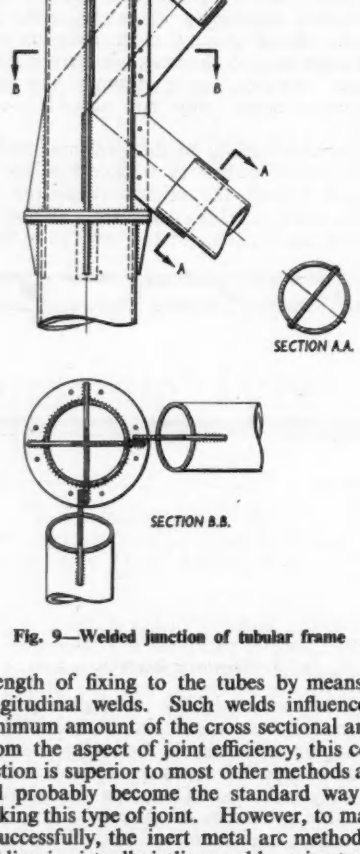


Fig. 9—Welded junction of tubular frame

At the base of tubular towers it has been normal to utilise welded galvanised steel components, as, in this application, aluminium can seldom be adopted to advantage.

Applications

The range and variety of the possible applications of these large diameter tubes is extremely wide and as experience grows and technique improves, no doubt the range will widen even further.

Single tapered tubular towers up to 100ft in height and 4ft 6in in diameter have been proposed or fabricated for use as transmission towers, lighting towers, and lamp standards. In such applications a weight reduction to one-quarter is normally attainable in comparison with traditional materials.

By using fabricated tubes in latticed structures, the number of members can be reduced appreciably and the overall efficiency so increased that latticed aluminium towers can be as low in weight as one-sixth of an equivalent steel construction composed of angle sections.

Other proposals include various forms of transmission towers, supporting frames for bridge structures, canopy roofs and certain types of crane masts.

Conclusion

It is interesting to note that, early in the career of steel as a structural material, attention was turned to large tubes as compression members because of their efficiency, but they are now rarely employed because of the cheaper and more readily fabricated forms which have been developed. Whether, because of the ease with which aluminium can be formed and jointed, this structural component will continue to grow in use, is impossible to predict, but during this period in which aluminium is still questing markets in the structural field, large diameter tubes are providing an economic solution for a number of design problems.

South African Oil-From-Coal Plant

Construction work on " Sasol," the new South African oil-from-coal plant, is well up to schedule and good progress is being maintained in the building of the various synthesis and processing units. The first section of this undertaking went into operation in June last, when the first four boilers in the power station were fired—two years after work began on the site.

These boilers, capable of developing 350,000 lb of steam per hour, are by far the largest in use in the country and will be exceeded in size and capacity only by those being installed in the Taaibos power station nearby. Other sections of the plant will be started in sequence according to process flow and it is hoped that a steady supply of petrol will be produced not later than the end of the first quarter of next year. It may be possible to go into production before that date as some of the sections may be able to run with partial production.

The first portion of the works to be completed will be the oxygen and gasification plants, and the catalyst synthesis units. It is expected that the power station will be finished in November. The gas produced by the gasifiers is passed over the catalysts and then converted into crude oil, which is refined into petrol and other products. These units will be tested thoroughly for several months as they begin to operate.

Although " Sasol " will cost in the region of £30,000,000, it is estimated that it will save the Union some £7,000,000 annually in foreign exchange. The plant will have a very much larger output than that originally planned—70,000,000 gallons of oil products per annum as against 30,000,000. The larger plant will, it is expected, lead to more efficient and more profitable operation, while, in addition, certain by-products that would have otherwise been wasted will be converted into marketable products.

The plant will be supplied with coal from the Sigma Colliery, situated about 2 miles west of the Coalbrook station. Three coal horizons have been proved. The upper seam occurs at a depth of about 370ft and has an average thickness of 11ft in the area being mined first. The middle seam, which will be the first to be extracted, is 24ft thick and occurs at a depth of about 420ft in this portion. Below this bed is another narrow seam.

The inclined shaft is the biggest of its kind in any coal mine in the country. It will be equipped with a 48in wide conveyor belt, capable of hauling 650 tons per hour, which will bring the coal to the surface and convey it to the works. An output of 7600 tons of crushed and screened coal will be obtained per day.

International Motor Show

No. II—(*Concluded from page 553, October 22nd*)

LAST week we dealt with medium-sized and moderately priced cars, made in large-scale production by the five big concerns which between them account for almost 90 per cent of this country's production. We now turn to the more expensive cars, which are made by specialist firms, and enjoy a high reputation mainly because of their excellent workmanship. In this particular field the design, although as a rule still orthodox, is more flexible than that of mass-produced cars, and we find, especially among the fast touring and sports cars, some good examples of the more adventurous aspects of automobile engineering.

At the stand of Jaguar Cars, Ltd., attention focuses on the new Mark VII 3½-litre type "M" saloon which, apart from other minor modifications, differs from its predecessor mainly by the increased output of the twin overhead camshaft engine which, by employing high-lift cams, has been raised from the previous 160 b.h.p. at 5200 r.p.m. to 190 b.h.p. at 5500 r.p.m. With a close-ratio gearbox, improved transmission and suspension, the car is capable of exceeding the 100 m.p.h. of the model it supersedes, but is claimed to be just as flexible. In addition to the normal gearbox, a five-speed transmission with overdrive is available or, for export only, the Borg Warner automatic transmission.

Among those cars which are less distinguished by very high speed, but by such properties as responsiveness, silence and longevity, we noticed five new models at the stand of the Daimler Company, Ltd., all of them based on variants of two engines and two chassis. The chassis are more or less conventional, built from box-sectioned longitudinal members and tubular cross members, strengthened by a large cruciform structure. They are identical in practically all dimensions and in the arrangement of such details as suspension, steering, transmission, &c., all of which are entirely in accordance with the traditional Daimler practice. The engines, both six-cylinders of 3·5 and 4·6-litre capacity, have the same stroke of 108mm, the bore of the smaller engine being 82·5mm and that of the larger 95·3mm, and develop at the moderate compression ratio of 6·5 : 1, 107 b.h.p. at 4000 r.p.m. and 127 b.h.p. at 3600 r.p.m. respectively. They are characterised by such details as a water-jacketed inlet manifold, dry cylinder liners and hard valve inserts. The transmission layout also follows the usual Daimler practice by using the familiar fluid flywheel and the preselective epicyclic gearbox. The 3·5-litre car is equipped with Girling hydro-mechanical brakes with two leading shoes at the front, and the 4·6-litre car has a full hydraulic system with a vacuum booster and two trailing shoes at the front. A special 3·5-litre "Sportsman Saloon" has a high-performance engine with an aluminium cylinder head which, at a compression ratio of 7·6 : 1, develops 140 b.h.p. at 4400 r.p.m. and has a maximum b.m.e.p. of 145 lb per square inch at 2500 r.p.m.

The 3·4-litre "Sapphire" of Armstrong-Siddeley Motors, Ltd., which at the 1952 show was greatly acclaimed for its pleasing appearance and the interesting design of its engine, is shown again with only minor modifications. In addition to the two previously available transmissions, either the normal dry plate clutch with four-speed synchromesh gearbox or the centrifugal clutch with electrically operated preselector gear, the "Sapphire" is now being offered with a third system, namely a British-built fully automatic transmission which dispenses with the clutch pedal, giving two-pedal (brake and accelerator) control. The system, first introduced at last year's show by Rolls-Royce and Bentley, is based on the "Hydra-Matic" unit of General Motors and consists of a fluid coupling, not intended for torque multiplication, and a four-speed epicyclic gearbox, automatically operated by hydraulic pressure in response to road speed and engine torque. The British version differs from the American, in that provision is made for an overriding hand control. Another useful innovation in the new car is the vacuum-assisted hydraulic brake system, which comprises two trailing shoes at the front with automatic slack adjustors. As the dry weight of the car is only 31 cwt and the power-to-weight ratio about 80 b.h.p. per ton, it should give a good performance.

Another new car, also equipped with an automatic transmission, is the four-five-seater saloon "Sprite" of the Lanchester Motor Company, Ltd. (Fig. 8). This car, fitted with a 1·6-litre four-cylinder engine and capable of a top speed in excess of 80 m.p.h., is probably the greatest surprise at this year's show, as it deviates in general layout as well as in detail design from previous Lanchester practice. It is of integral construction, the structure being suitably reinforced by cross members to carry mechanical units and passenger seating, without resorting to any vestigial chassis frame. Light metal is used for the door panels, the bonnet and the lid of the luggage boot, resulting in a substantial reduction of weight. The rear suspension is of the conventional design, using semi-elliptic springs on connection with telescopic dampers, but the previously used torsion bar suspension at the front has been replaced by an assembly of pressed wishbones of uneven length and coil springs with enclosed telescopic dampers. The 1·6-litre four-cylinder engine of 89mm stroke and 76·2mm bore has pushrod-operated overhead valves and develops 60 b.h.p. at 4200 r.p.m. Its design is based on that of the six-cylinder 2·5-litre engine of the Daimler "Conquest"; it has the same bore and stroke and can be regarded as the four-cylinder version of the latter.

The most interesting component of the car is the automatic transmission which is not offered as an optional extra, but belongs to the standard equipment of the "Sprite." It is an all-British invention and has been developed by Lanchester under Hobbs patents. The transmission differs from other known systems in as far as it has a mechanical drive and uses hydraulic power only for the engagement of the two main friction clutches and for operating the brakes of the epicyclic gear trains which control the selection of the four forward ratios and reverse. A detailed description of the Hobbs gearbox was given in our report on the fifteenth Commercial Motor Show in THE ENGINEER of November 3, 1950, and we therefore confine ourselves to outlining its operation by the driver.

The manual control on the steering column is graduated to read N (neutral), 1, 2, 3, 4, A (automatic) and R (reverse). Normal driving with the control in "A" position gives a start from rest through an automatic clutch in second gear, changing automatically to third and top after the car is in motion; the gear change is completed by the time the car reaches a speed of 25 m.p.h. On coming to rest in traffic, the car reverts to the starting position in second gear. By depressing the accelerator pedal slightly past the fully open position against a spring-loaded stop, a kick-down valve is brought into operation which extends the range of the second and third gear up to the speed limit which is permissible in each individual gear. The kick-down arrangement can be utilised at any time when in top gear, if extra acceleration is required for passing or hill climbing. By placing the manual control into third position, the operation from rest is exactly as previously described, except that the change-up is restricted to the third gear. If the gear lever is put into second it remains in second until manually changed to another gear. First gear is only obtainable by the use of the selector lever under manual control, and is provided only as an emergency low gear.

As already mentioned, the transmission is entirely mechanical and not subject to hydraulic losses or idling drag which, to a certain extent affect the overall efficiency of the fluid coupling or the hydrodynamic torque converter. For this reason it seems most suitable in conjunction with small and medium-sized engines where even small losses of this kind are undesirable. In view of the growing importance of automatic and semi-automatic transmissions for the future development of cars it will be of great interest to learn more about the performance of the Lanchester-Hobbs gear in prolonged road tests and under severe operational conditions.

Before concluding our review of British cars we should like to mention two new models which were not announced until the opening day of the show and so were not included in Part I of our article, which dealt with the products of the five big motor manufacturers. They are the new Wolseley "Six-Ninety" and the Austin A90 "Six," which is to be known as "Westminster."

The "Six-Ninety" differs from its predecessor "Six-Eighty" not only, as the name seems to indicate, by an engine of greater output but in its whole conception and in the design of most of the major components (Fig. 9). The former integral construction has been discarded in favour of an all-steel body mounted on a conventional chassis. The torsion bar front suspension previously used has been maintained, though suitably modified, but the rear suspension has been completely redesigned. Instead of the former semi-elliptic leaf springs the suspension now employs coil springs in conjunction with radius arms which extend forwards and inwards towards a rubber-mounted pivot attached to a cross member (Fig. 12). A transverse Panhard rod, connecting one side of the rigid rear axle with the longitudinal chassis member, limits the lateral movement of the axle. The layout of the transmission follows orthodox practice. The former 2·2 litre overhead camshaft engine has been replaced by an entirely new power unit of 2·64 litre capacity, known as the M.B.C. series "C" engine. The engine has six cylinders of 89mm stroke and 79·4mm bore, a compression ratio of 7·3 : 1, and it develops 95 b.h.p. at 4500 r.p.m. It has push-rod-operated overhead valves, separate inlet and exhaust ports, and a chain-driven camshaft positioned on the right-hand side of the cylinder block, i.e. opposite to the inlet and exhaust manifold. The Wolseley "Six-Ninety" weighs dry about 30 cwt. and, with a power-to-weight ratio of about 60 b.h.p. per ton, should have a very good performance.

Fig. 8—Lanchester "Sprite" with an engine developing 60 b.h.p. at 4200 r.p.m.

Fig. 9—Wolseley "6/90" integral saloon with coil spring rear suspension

Fig. 10—Mercedes-Benz two-seater sports coupe "300 SL"

Fig. 11—Lancia "Aurelia" series 2 Gran Turismo 2500 with De Dion axle assembly

The Austin "Westminster" is not a modified "A70," but an entirely new car which neither in appearance nor in its mechanical layout has any resemblance to the old model it supersedes. The car, a roomy four-five-seater, four-door saloon, can best be described as a bigger version of the Austin "Cambridge." Like the latter, it is built in integral stressed-skin construction and has the same pleasing lines, the horizontal radiator grille and the air scoop at the top of the bonnet. In accordance with the rationalisation policy of the British Motor Corporation it employs the same engine as the Wolseley "Six-Ninety," which, in this case, is fitted with a Zenith carburettor and a mechanically operated fuel pump instead of the two S.U. carburettors and the electric rear-mounted S.U. fuel pump of the Wolseley. In order to suit the characteristics of the "Westminster," the engine speed has been reduced to 4000 r.p.m. and the output to 85 b.h.p.

With such detail modifications as hypoid rear axle drive, hydraulic clutch operation, improved steering and gear change mechanism, the "Westminster" is greatly superior to the old "A 70."

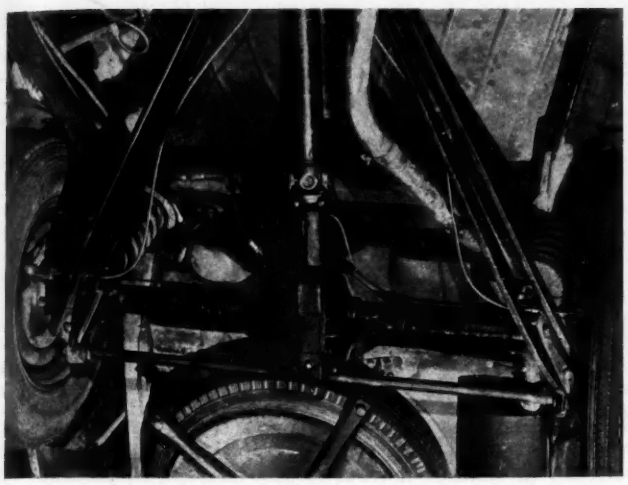


Fig. 12—Rear suspension of the Riley "Pathfinder" which, in conjunction with a Panhard rod, is basically similar to the Wolseley "6/90"

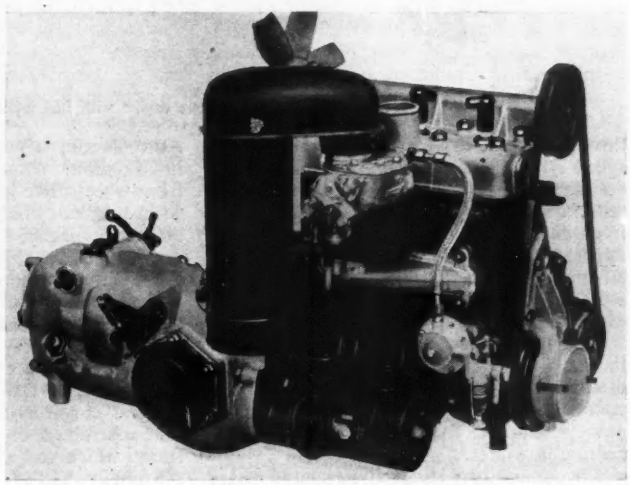


Fig. 13—D.K.W. three-cylinder, 900 c.c., two-stroke engine and drive unit

Foreign Cars

Turning now to the cars of foreign origin, we noticed that the American manufacturers are again represented in full strength; not less than seventeen firms are displaying an impressive collection of mainly new models made in U.S.A. and Canada, not intended for sale here, but in such overseas countries which have no import and currency restrictions.

Although the American cars are offered in many differing body styles—Chevrolet, for instance, offers not less than seventeen—they seem to look almost uniform to the non-initiated, and it is difficult even for the expert to distinguish between the various makes. A closer inspection of the exhibits does not help to clarify matters very much, for in the absence of demonstration models or exploded units it is not easy to assess their technical details. However, there seems no indication of any drastic change in the well-known conception of the American car, and such modifications as we were able to notice are almost entirely confined to body styling. It appears that the American body style this year is more than ever before influenced by Continental, in particular Italian, influence. This tendency has markedly contributed to their elegance and æsthetic appeal, though in some cases the graceful lines of an originally pleasing design have been obliterated to a certain extent by the heavy ornamentation of the air intake grille and the bumpers. One of the most radical changes in body design is the steeply raked and sharply curved-back windscreen to be seen on some of the latest American cars; other styling features include large wrapped-round rear windows, transparent roofs, and long flowing lines resembling stabilising fins at the rear wings. The finish and equipment of American cars is excellent and, measured by European standards, almost lavish; air conditioning, heating, and power operation of folding roofs, window winders, and seat adjustment are standard equipment in cars of higher price.

No major alterations are apparent in the mechanical layout which is characterised by high-powered engines of ample cylinder capacity, automatic transmissions, orthodox chassis design and suspensions which comprise wishbones and coil springs at the front and rigid live axles with semi-elliptic leaf springs at the rear. Engines of less than 3-litre cylinder capacity and 100 b.h.p. output are rare. Those of more than 4-litre capacity, with very few exceptions, have eight cylinders arranged in vee form with an included angle of 90 deg. Compression ratios on the whole are higher than in this country and on the Continent, approaching ratios of 8 : 1 and more, as high-octane petrol is taken for granted in America and because the automatic transmission effectively limits excessive full-throttle operation of the engine. Most medium-priced cars are offered with clutch and conventional three-speed gearbox, augmented optionally by an overspeed gear, but the automatic transmission is always available at extra cost. These automatic transmissions are, as a rule, of the well-known kinds, employing hydraulic torque converters, either of a moderate conversion ratio in conjunction with epicyclic four-speed gearboxes or converters with high torque multiplication allied to two-speed gears. Other less elaborate systems consisting of torque converters or fluid couplings and conventional three-speed gearboxes with or without additional friction clutches are also in use. Power assistance for steering and brake operation is either standard equipment or, for cheaper cars, obtainable as an optional extra.

It is impossible in this short survey to give any detailed descriptions of the numerous American cars, but we should like to mention just a few, a closer study of which should be interesting for the engineer. At the stand of Cadillac attention is focused on the two-seater "Eldorado," an interesting vehicle of General Motors Corporation, fitted with a 5·6-litre 230 h.p. engine, which has a completely streamlined body.

The American Ford Company prominently displays a two-seater roadster, the "Thunderbird," a well-styled car with a 4·2-litre engine of 160 h.p., while at the Chrysler stand the "New Yorker" attracts most of the visitors. The "New Yorker" is a de luxe saloon with a 5·4-litre vee-eight engine with pushrod-operated valves in a hemispherical combustion chamber which develops 235 b.h.p. at 4400 r.p.m. and is claimed to be the most powerful engine used in a standard production car. Another interesting car is the Willys-Overland "Aero Ace," one of the few American cars built in integral construction. This roomy six-seater two-door saloon has a 2·6-litre engine of 90 h.p. with o.h. inlet and side exhaust valve. British visitors to the show are likely to take an interest in the Austin-built Nash "Metropolitan" two-seater hard-top coupé, a car which incorporates an Austin "A40" engine, a modified "A30" gearbox and other Austin parts. Though built in this country, the car is for export only and is marketed by the Nash-Kelvinator Corporation, Detroit.

France is represented at the show by five firms showing a number of models which differ from those exhibited last year in minor details only. The only new car is the "Vedette," displayed by the French Ford works, which are now under all-French control as part of the Simca organisation.

The "Vedette" is a well-styled, roomy six-seater of integral construction, suitably stiffened at the front by a box-shaped subframe to support the suspension and the steering assembly. The front suspension is similar to that of the British Ford models, comprising long coil springs with enclosed telescopic dampers and lower wishbones only. At the rear the semi-floating hypoid axle is supported by semi-elliptic leaf springs in conjunction with telescopic dampers. The 2·35-litre side-valve engine has eight cylinders of 85·7mm stroke and 66mm bore, arranged in vee form with an included angle of 90 deg. The engine has a compression ratio of 7·2 : 1 and develops 80 b.h.p. at 4600 r.p.m. The torque is transmitted

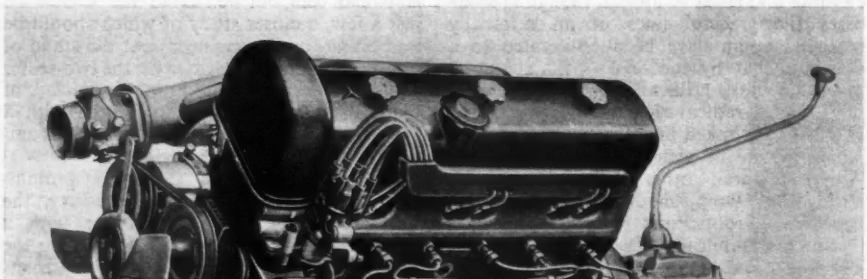


Fig. 14—3-litre Mercedes-Benz engine with fuel injection

through a single dry-plate clutch and a three-speed synchromesh gearbox, having steering column control. The exhibited model, a sedan de luxe, to be known as "Versailles," is an example of good body styling, and the appearance with its very large glass area all round, is rather striking. The car weighs only 22½ cwt. and is claimed to be capable of a maximum speed of 90 m.p.h.

The rear-engined Renault "4 CV" is still the most popular car in France, and the only modification considered necessary this year concerns the water-cooling system, which is now pressurised to provide better interior heating in winter.

The popularity of the small Renault appears to be challenged by the air-cooled, twin-cylinder, front-wheel drive Citröen "2 CV" which is said to be the most sought-after car in France. Originally disparaged by the public because of its unusual, though entirely functional, appearance and its austere finish, the exceptional performance of this economic little runabout has become so manifest that the manufacturers are unable to cope with the increasing demand. The car is now being offered with a new 425 c.c. engine, developing 12 b.h.p. at 3600 r.p.m., instead of the standard 375 c.c. engine of 9 b.h.p.

A new device, not shown on the three Citröen models displayed at Earls Court, is intended to facilitate the gear change operation. It consists of a centrifugal clutch, interposed between the flywheel and the conventional single dry-plate clutch, which frees the drive when the engine speed drops below 1000 r.p.m. The centrifugal clutch is so dimensioned that it can take the full torque when starting from rest simply by accelerating the engine. Gear changes at an engine speed exceeding 1000 r.p.m. have to be made by using the pedal of the normal clutch. An automatic stop prevents stalling of the engine by making the closed position of the throttle independent of that of the accelerator. Although this Citröen device is not intended as a substitute for the semi-automatic gear, it greatly facilitates driving in heavy traffic where frequent stopping and restarting is required.

In this connection it is worth mentioning that in this country as well as abroad many new automatic clutches are in the process of development. They will sooner or later help to solve the difficult problem of effecting an easy gear shift in small cars where the cost of a fully automatic or even semi-automatic transmission would be prohibitive.

The German contingent at the show is represented by six firms, one of which, the Auto Union, is making its first appearance in London. Its product, the D.K.W. front-wheel drive car "Sonderklasse," fitted with a three-cylinder, two-stroke engine of 900 c.c. capacity, has not been seen in this country before, although it is well-known on the Continent where it is leading in the 1954 International Touring Car Championship (restricted to standard production models) and has won every event in the 1-litre class in which it has been entered.

The car, a four-seater saloon of semi-integral construction, has the engine drive unit assembled on a "wheelbarrow" sub-frame which can easily be withdrawn from the main body. It contains a three-cylinder engine, mounted in front of the drive axles and the radiator, a four-speed synchromesh gearbox which is integral with the spiral-bevel final drive, and the driven front wheels which are suspended by a system of triangulated wishbones with a transverse leaf spring. The rear suspension consists of a light, rigid axle, also suspended by a transverse leaf spring, the pivot point of which is located at the rear cross member of the chassis above the centre of gravity of the sprung masses. The centrifugal forces at cornering, acting on this centre, therefore, induce a moment about the longitudinal roll axis which counteracts the tendency of the car body to heel outwards. For this reason the car, in spite of its comparatively short wheelbase of 7ft 8½in has a high degree of directional stability and resistance to rolling.

The engine, the only two-stroke engine at the show, employs the simple but effective system of loop scavanging with piston controlled ports in conjunction with crankcase scavenging. It has three cylinders of 76mm stroke and 71mm bore, a cylinder capacity of 900 c.c. and, with a compression ratio of 6·5 : 1, develops 34 b.h.p. at 4000 r.p.m. (Fig. 13). The cast iron cylinder block is integral with the crankcase and carries the built-up crankshaft in three ball bearings. No oil pump is provided, the lubrication being effected by prior admixture of oil in proportion of about 1 : 25 with the fuel. The engine, in spite of its inherent simplicity, has almost the same flexibility and torque characteristic as a six-cylinder, four-stroke engine, but is somewhat noisier than the latter, especially at idling speed. For obvious reasons its fuel and oil consumption is slightly higher than that of a four-stroke engine, though this difference is hardly noticeable in actual road performance because of the interposition of a free wheel device between clutch and gearbox which, properly used, considerably reduces the number of engine revolutions per mile with a marked effect on fuel economy and cylinder wear.

Another interesting German exhibit is the Porsche "Spyder" two-seater, a sports car with a fully streamlined body, capable of a maximum speed in excess of 140 m.p.h. The notable technical feature of the car, which is based on the original "Volkswagen" design, is the air-cooled, horizontally opposed, 1·5-litre, four-cylinder engine of 66mm stroke and 85mm bore; it has the high compression ratio of 9 : 1 and develops 110 b.h.p. at 7000 r.p.m. This output, equivalent to about 73 b.h.p. per litre, is unusually high for an air-cooled engine and must be attributed to such design details as twin overhead camshafts for each of the two cylinder banks, chromium-plated aluminium cylinder barrels, and roller bearings for the built-up crankshaft and the connecting-rods.

It is only natural that, after the successes gained this year in International Grand Prix racing, the stand of Mercédès-Benz is one of the main attractions among the foreign exhibits. One of the first pioneers in the automobile industry, this firm has always made a point of incorporating lessons, acquired in racing practice, into production cars. A striking example of this policy, prominently displayed at the Mercédès stand, is a two-seater sports coupé "300 SL" (Fig. 10),

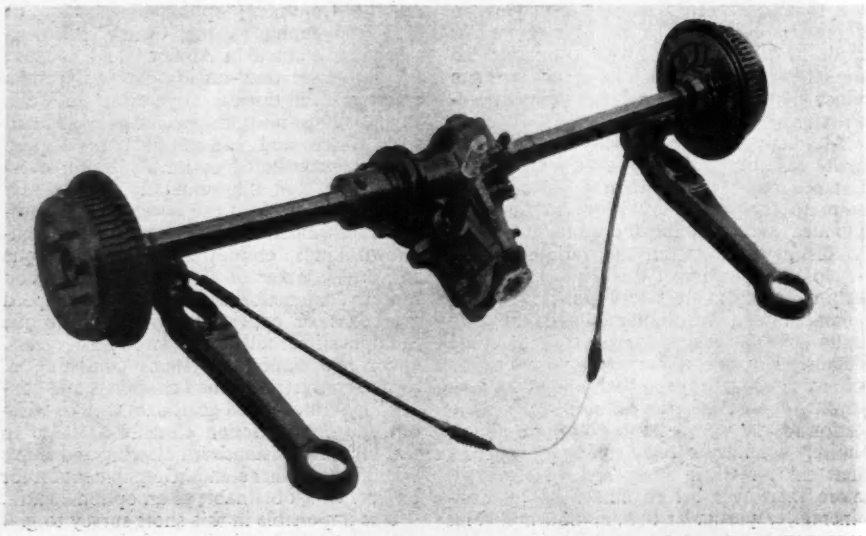


Fig. 15—Mercedes-Benz single-jointed swing axle showing brake drums with cooling fins

a car of the same basic design and of similar appearance as the Mercédès sports cars which in 1952 won victories in such international events as the Berne and Le Mans races, the Grand Prix of Germany and the Carrera Panamericana.

The car has a light three-dimensional tubular frame, the individual members of which theoretically are subject to compressive and tensile stresses only, but not to bending. All wheels are independently sprung : the front suspension has double wishbones and coil springs, the rear suspension consists of a double-jointed swing axle, also supported by coil springs. The torque is transmitted through a four-speed synchro-mesh gearbox, mounted to the engine, and an open propeller shaft to the final gear casing which is attached to the frame. The brakes have Alfin bi-metal drums with ventilating fins and are operated by servo-assisted oil pressure. In order to facilitate the entrance into the very low car, the total height of which is only 4ft 4in, the doors open upwards, and the steering wheel can be swivelled about a pin attached to the steering shaft. The car weighs dry about 23 cwt, and is said to be capable of a maximum speed in excess of 160 m.p.h.

Its 3-litre, six-cylinder engine has an overhead camshaft driven by a duplex roller chain, and is mounted in a tilted position to secure a low bonnet line ; with a stroke of 88mm and a bore of 85mm it develops, at a compression ratio of 8·55 : 1, 240 b.h.p. at 6100 r.p.m. (Fig. 14). It is the first engine ever installed in a production car to be fitted with fuel injection. The system comprises a Bosch injection pump, similar in design to that of the well-known diesel injection pump, and spring-loaded nozzles for the individual cylinders. The fuel is injected during the suction stroke, and the control of the injected volume is effected by means of a pneumatic governor in response to the vacuum in the inlet manifold, i.e. in relation to the throttle opening. A thermostat and an altitude compensator correct any variations in the ambient temperature and in the air intensity, so that the strength of the mixture remains constant irrespective of temperature and atmospheric conditions.

Compared to the conventional carburetter, fuel injection for spark-ignition engines has several advantages, only a few of which can be enumerated in this report. It gives increased power and increased economy due to better filling, resulting from the removal of the choke, redesign of the inlet manifold and absence of intake charge heating. It reduces the octane requirement of the engine, resulting from the cooler and better equalised charge, and allows the use of higher compression ratios. Fuel injection can increase the engine output by as much as 20 per cent and its economy by 10 to 15 per cent with considerable improvements in the obtainable torque characteristic. Owing to the high cost of the injection equipment the system will be restricted at present to expensive high-performance engines, but a more general application can be safely predicted in the near future.

Less spectacular than the sports coupé is the Mercédès-Benz type " 220 a," a recently introduced six-seater saloon of integral construction fitted with a six-cylinder 2·2-litre engine of 85 b.h.p. The original layout of its rear swing axle is of considerable interest. Contrary to previous Mercédès practice, it employs only one universal joint instead of two (Fig. 15). The casing of the hypoid final drive unit is carried in a bracket secured to the frame by means of a rubber mounting. It is free to pivot, together with the firmly attached left-hand axle tube, half axle and differential about a pin carried in two lugs of the above bracket. The axis of the pin is parallel to, but positioned below, the axis of the propeller shaft ; the pin is also the pivot of the right-hand axle tube, and is in line with the centre of the universal joint which connects the right-hand half axle with the differential assembly. As both axles pivot about the same axis, approximately in the centre line of the car, their individual length has obtained the maximum value, and the change of camber angle, as the wheels move up and down, is smaller than that of the previous design. Further, as the pivot point is below the centre of the propeller shaft, the roll centre is also lowered, resulting in improved road-holding properties when cornering fast, and in a reduction of tyre wear. In other respects the new rear axle assembly resembles the old one and it also employs rubber-mounted trailing arms on each side and coil springs with telescopic dampers. Improved brake cooling is effected by radial fins at the circumference of the brake drums, which increase the circulation of air entering through slots in the wheel discs.

Italian motor manufacturers this year are again represented by such well-known firms as Alfa-Romeo, Fiat, and Lancia.

The Fiat range continues without any noticeable changes, but Alfa-Romeo introduces a new two-seater sports coupé " Giuilietta." The car has an orthodox chassis and a conventional transmission and differs from established practice mainly by its suspension system which employs variable-rate coil springs in the wishbone layout at the front and variable-rate leaf springs at the rear. The 1·3-litre four-cylinder engine of 75mm stroke and 74mm bore has a compression ratio of 8 : 1 and develops 65 b.h.p. at 6000 r.p.m. It has a light metal cylinder head, hemispherical combustion chambers and inclined valves, actuated by two chain-driven overhead camshafts. The car weighs 16 cwt and is claimed to exceed a maximum speed of 100 m.p.h.

The Lancia " Aurelia " models, the 2·5-litre " Aurelia " Gran Turismo, displayed as a well-styled two-seater sports sedan (Fig. 11), and the " Aurelia " Series II, have not changed much in appearance. The vee-60 deg. six-cylinder engine of the " Aurelia " Series II has now a cylinder capacity of 2·3 litres instead of the former 2 litres, but its output is slightly smaller, as the maximum engine speed has been reduced from 5000 to 4300 r.p.m. There is, however, a fundamental deviation from customary Lancia practice in the modified layout of the rear suspension. The combined gearbox final drive unit, mounted together with the large inboard brakes to the integral body frame, has been retained, but the former swing axle assembly incorporating coil springs and trailing arms has been discarded in favour of a tubular De Dion axle, suspended by narrow semi-elliptic unsymmetrical leaf springs. A Panhard rod and inclined telescopic dampers relieve the springs from lateral stresses.

This rather surprising change—though by no means unprecedented in the history of automobile engineering—might come as a surprise or even considered a retrograde step by the " progressive " school of automobile engineering. It can be assumed, however, that Lancia's decision was probably based on experience gained in road tests carried out with their newly developed Grand Prix racing cars.

We conclude our report with a short description of the only car from the other side of the iron curtain which has ever been publicly displayed in this country after the war. The Czechoslovak Skoda is a four-seater four-door saloon of modern, though rather austere appearance, fitted with a 1·2-litre four-cylinder pushrod operated o.h.v. engine which develops 36 b.h.p. at 4000 r.p.m.

The car has a tubular backbone chassis which, together with outriggers, forms the basis for the all-steel body and encloses the propeller shaft. The torque is transmitted via a single dry plate clutch and a four-speed synchromesh gearbox to the spiral bevel final drive unit, which is rubber mounted to the frame. The front suspension employs upper wishbones and a transverse leaf spring, and the rear swing axle is also supported by a transverse spring.

Supersonic Delta Aircraft

THE second supersonic aircraft to fly in the Ministry of Supply's research programme is the Fairey " Delta 2." This machine as originally conceived was to be concerned with near sonic speeds, but in the course of its design and development it became clear that this range of speeds would be exceeded. It will be used to investigate the characteristics of flight and control at transonic and supersonic speeds on level flight, and its design has been supported by a particularly comprehensive programme of model trials.

The " F.D.2 " is a single seat, midwing delta aircraft, powered by a Rolls-Royce " Avon " engine. An exceptionally thin wing is claimed for it and the trailing edge is described as " sword-edged." In spite of this wing section, however, the company has designed an undercarriage which can be fully retracted in the wing.

A streamlined elongated nose carries an air speed indicator pitot head at its extremity. The whole of the nose section can be, and is, lowered in flight by the pilot (somewhat in the manner of a drawbridge) to secure a good forward view for landing, take-off and taxying. In normal flight the movable nose is aligned to the datum line of the aircraft.

Fairey " F2 " supersonic delta research aircraft

Shepherd's Bush Garage

The London Transport Executive has recently completed two new bus garages, one at Brixton and one at Shepherd's Bush. The Shepherd's Bush garage has a reinforced concrete structure of rather unusual design, which is briefly described hereunder.

THE recent improvement schemes carried out by the London Transport Executive have included the provision of several new bus garages. Two of these buildings, both of them built on the sites of older garages, have now been completed, one at Brixton and one at Shepherd's Bush. The Brixton garage is a steel-framed structure, the main spans consisting of lattice girders, 14ft deep and spanning 173ft 6in on to stanchions, with balanced cantilever trusses 25ft long on each side. This design does not depart substantially from the generally accepted standards of steelwork design, and thus need not be described further here. But the Shepherd's Bush garage, which has a reinforced concrete structural frame, is rather more unusual in its conception. It may be recalled that the garage at Stockwell was described in THE ENGINEER of October 30, 1953; it consisted structurally of reinforced concrete arched ribs spanning almost 200ft and was an entirely new building. The Shepherd's Bush garage makes use of a different system of structural framework, which was devised for use on a restricted site, part of which was already occupied by a bus garage dating from 1906. A requirement of the work was that the garage should be kept in operation throughout the rebuilding. Both the Stockwell and Shepherd's Bush garages were built of reinforced concrete rather than of structural steel because of the L.T.E.'s policy at the time that they were designed, which followed the Government's request to economise in steel consumption during a period of shortage; the relative costs of steel and concrete designs were, we understand, not significantly different.

The Stockwell garage accommodates 200 buses, the Brixton garage 108 buses, and the Shepherd's Bush garage, as at present built, 123 buses; an extension planned for Shepherd's Bush garage will allow twenty-five more buses to be housed.

LAYOUT OF SHEPHERD'S BUSH GARAGE

The site of the new garage at Shepherd's Bush is irregular in shape, and at the start of the work the eastern and southern sides were clear of the old garage, and so work was started there. A new entrance and servicing area was built on the southern side, consisting of reinforced concrete portal frames spanning 48ft; this area is at about 45 deg. with the main axis of the building. The area at the east end accommodates inspection pits and workshops.

The main parking area of the new garage extends over 45,300 square feet. It is covered by a series of box beams, running from east to west. The main transverse members, which carry these box beams vary through the length of the garage, to suit the particular conditions imposed at each stage. At the inspection pits there is a beam and column system. The box beams span 52ft over the inspection pits and are supported at the open end of the pits on the garage side by a deep I-beam, 10ft 10in deep and 4ft 9in wide on the bottom flange, spanning 99ft, and carried for a further 33ft along the side of the garage. The box beams then span a further 34ft 6in to a bowstring girder; a cross-section at the bowstring girder is shown in the illustration on this page, which clearly shows the structural layout at this point.

The stage of construction just described—up to and including the large bowstring girder—was carried out before the old garage was interfered with. However, in the next stages it became necessary to encroach upon the old garage, and gradually replace it. But some alternative space was already available, with the new entrance on the southern side, and as the work progressed sufficient space for the buses was kept available all the time. When construction was further advanced the garage boundary was widened along the line of the bowstring girder for 66ft to the north along the edge of the old garage.

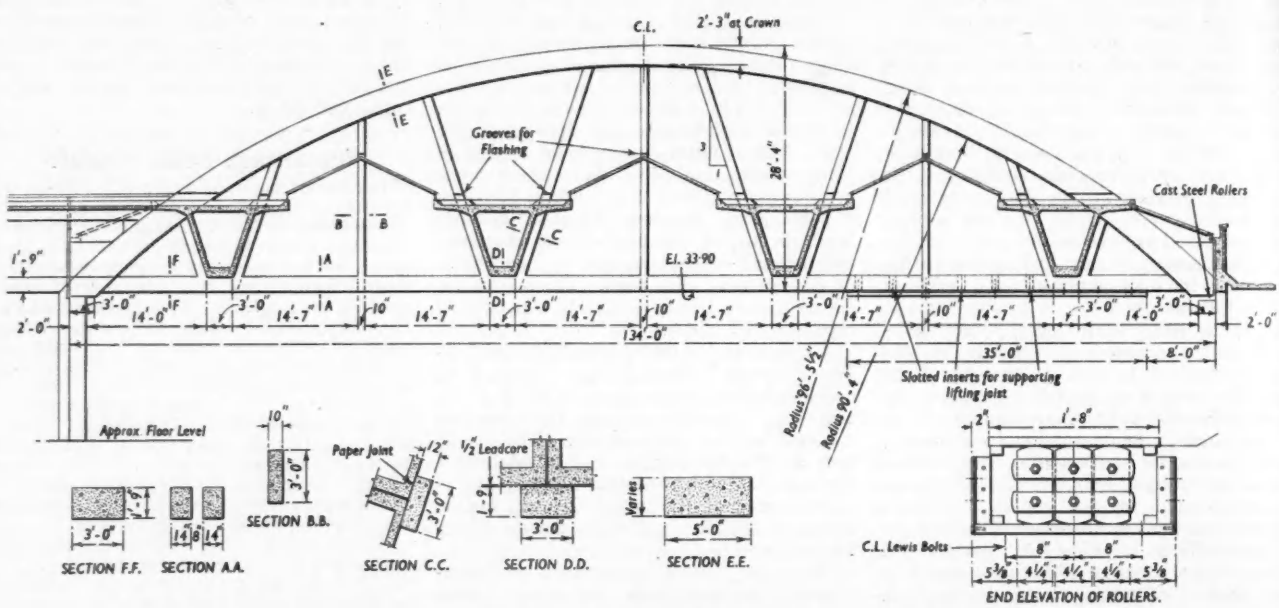
Continuing westwards from the bowstring girder illustrated, the box beams span a distance of 108ft. The three beams on the right-hand side in the cross-section are carried, at the other end of the 108ft span, on a similar but smaller bowstring girder. This girder supports one box beam at mid-span and one at each quarter point. There is a similar bowstring girder next to it, carrying the fourth box beam, and two further ones, which spring from a beam and column system along the boundary wall of the garage, where it widens out along the line of the larger girder. Thus a total area of 108ft by 198ft (the two smaller bowstrings each span 99ft) is enclosed by this system.

The two smaller bowstrings rest on a common column at the centre. The completed garage will continue westwards from them for a further 94ft 6in—again spanned by the box beams—to the western boundary wall abutting on Wells Road. At present only half of this section—from the southerly bowstring—has been built. The three box beams are carried to a deep fascia beam over the Wells Road entrance, with which they are monolithic. Thus it will be seen that the main area of the finished garage will cover 192ft 6in by 198ft, with only one column, roughly in the centre, when the last 94ft 6in by 99ft section is built later on.

CONSTRUCTIONAL WORK

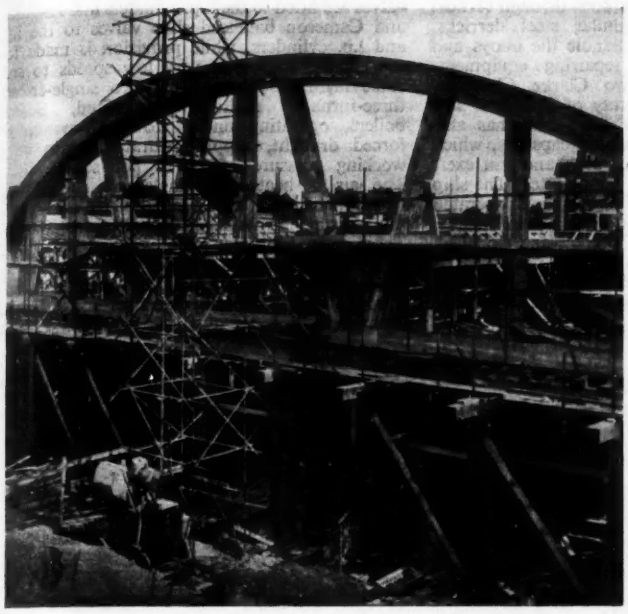
It will be apparent from the foregoing description that some massive reinforced concrete elements have been incorporated in the structure of the garage. The box beams, running from east to west, are spaced 33ft apart; they are 8ft deep overall, and are 8ft wide at the soffit of the compression flange, which is 16ft wide and of 5in average thickness; they taper to a bottom flange width of 3ft. The sides are 6in thick and the bottom flanges are 12in thick. Stiffening ribs are formed within the box beams and their ends consist of a diaphragm wall in which there is an access panel allowing passages from one box girder to another. Access to the box beams is provided through the top flange which forms part of the roof deck. The box beams accommodate the service pipes, electric conduits and rainwater pipes and have their own system of electric lighting. There is sufficient headroom for maintenance personnel to walk comfortably. Pitched decklights are provided between adjacent edges of the flanges of the box beams over a width of 17ft, consisting of glazing bars pitched to a ridge piece carried on trusses at intervals. The decklights over the central portion of the parking area have an uninterrupted length of 272ft, which provide exceptionally good lighting conditions.

The 132ft span bowstring girder, illustrated in cross-section, has a rise of 26ft 4in; the box beams give four point loads of 128 tons each. The horizontal thrust at the haunches is 437 tons and the vertical load at each support is 357 tons. The arch rib at the crown is 5ft wide by 2ft 3in deep, which increases to a depth of 3ft at the springing. Except at the ends, the tie members of the bowstring consist of twin 21in by 14in members, each containing eighteen 1½in diameter bars. The twin ties are united at the ends of the girder to give space for twelve additional 1½in diameter bars required for anchorage.



Details of reinforced concrete roof structure at Shepherd's Bush garage, showing the 132ft span bowstring girder carrying four box beams

The main bars were welded in 50ft lengths, using double-vee butt weld joints. The hangers are 3ft by 1ft and gaps were left in the concrete when they were cast to allow the bars in tension to develop their full extension under load before they were subsequently filled in ; thus cracking in the concrete was avoided. To avoid the transference of bending moments into the supporting columns a hinged connection is made at one end of the bowstring girders and a roller bearing is provided at the other. The roller bearing consists of 9in diameter cast steel rollers between two 1in thick cast steel plates, the lower plate is ragbolted to the column and the top plate secured to the underside of the haunch of the girders. The whole bearing is enclosed with thin metal plates and filled with lubricant.



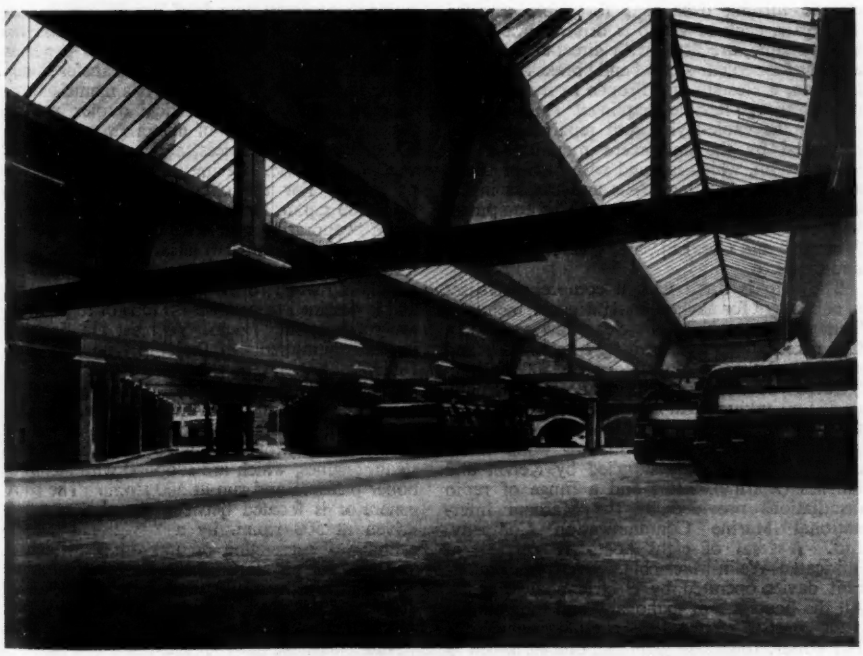
Erection of main bowstring girder showing timber falsework

The photographs reproduced with this article give an idea of the construction of the main bowstring girder and of the other reinforced concrete elements. As may be observed, timber falsework was used to build the bowstring girder. Several towers were first built up to tie beam level, where a working platform was built ; the reinforcing rods were welded together on this platform and the centering for the arch of the bowstring was supported from it ; a number of timber units for this part of the work were made on the roof of the servicing area and entrance, which by then had been completed, and which afforded the only convenient place for such work. A rather complicated sequence was observed in removing the props from the box beams spanning between the bowstring girders, so that asymmetrical loading conditions were avoided.

The design of the roof structure is noteworthy, in that fully articulated joints are provided between the principal elements. The hinge and roller bearing of the bowstring girders have already been noted. Where the box girders are seated on the I-beam and on the bowstring girders the contact surfaces have been separated by leadcore sheeting immediately at the bearing and by thick building paper at the sides of the hangers. Individual spans are separated by gaps which are filled with a compound which allows longitudinal movement.

The column heads of the beam and column systems round the boundaries have hinges built into them. The deep I-beam over the inspection pits was cast in two parts; this beam, it may be recalled, spans 99ft and 33ft. The larger span was cast first and allowed to take its full dead load before the second span was cast, thus avoiding a large negative moment over the interior support and enabling the same flange width to be maintained throughout the length of the bottom flange. The outside walls of the building are carried on reinforced concrete ground beams. The roof structure was designed for a superimposed loading of 30 lb per square foot, and its design followed the L.C.C. by-laws.

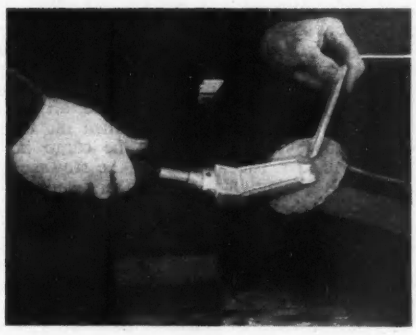
The consulting engineer responsible for the structural work for Shepherd's Bush garage was Mr. A. E. Beer, and the main contractor was Charles Booth and Son. The architects were Adie Button and Partners, associated with T. Bilbow, the London Transport Executive's architect, and the consulting engineers for the electrical installation were R. Edgar and Partners. The heating and ventilating equipment was installed under the supervision of Mr. H. Carter, the Executive's new works engineer.



The completed garage at Shepherd's Bush with the main bowstring girder in the foreground

Universal Filling Compound

DURING a recent visit to the Woodgate Works of Birmetals, Ltd., at Quinton, Birmingham, we were able to witness practical demonstrations of the application of new universal filling compound known as "Birmetals Filzall." This material, which is a compound of aluminium powder and thermal setting resins, is produced in bars of hexagonal section, of ¾in side, about 12in long, and it is claimed that the material can be applied successfully to aluminium, bronze, steel, iron, lead, stone, cement, glass and wood. It is non-toxic, does not give rise to objectionable fumes during application, and does not require the use of solvents or fluxes. The material, which can be kept indefinitely, is about one-fourth the weight of metallic solders and it is estimated that two sticks approximately 4 oz, are equal volume for volume to 1 lb of metallic solder.



Application of compound using electric paddle

"Filzall" is not a solder and cannot be used for joining metals but it can be used to prevent intimate contact between dissimilar metals and, being chemically inert, has no affinity for other metals. The compound has strong adherence characteristics so that it is particularly suitable for repairing damage to the bodies of motor vehicles or for filling the surface of stone, cement or wood. This adhesive power is strong enough to withstand the effect of vibration and test samples have been subjected to over 100 million reversals of stress in a machine, which set up a ¼in deflection in the test-piece, without impairing the strength of the adhesion. The shear strength is 390 lb per square inch. Among the advantages claimed for the filler is that the manner of application is simple and no special skill is required, and that it does not shrink or sink nor does it sag during use so that vertical surfaces can be readily treated. Final dressing of the surface offers no difficulty and the material hardens quickly so that it can be painted within a comparatively short time after application. It is understood that the filler is able to withstand a paint-stoving temperature of 130 deg. Cent.

For the application of "Filzall" all grease and dirt must be removed and the surface roughened with coarse glass-paper. To apply the filler the Birmetals, Ltd., supplies an electric paddle, which is available for 230V or 110V, and can be seen in use in our photograph, or a brazing torch can be used in association with wooden smoothing paddles. The electric paddle melts material from the filler stick and is used to spread it thinly, as in tinning, over the damaged area before proceeding to complete the filling-in operation. Smoothing can be carried out with the heel of the paddle and the surface can be finished with a rough file or a sander using the reverse face of the disc. Should a torch be used, the paint must be removed from the surface before roughing with glass-paper and the surface should be heated until it is hot enough to melt the filler when it is brought into contact with it.

Cable Steamship "Recorder"

THE latest addition to the fleet of Cable and Wireless, Ltd., is the C.S. "Recorder," which has been built and engined at the Neptune Shipyard of Swan, Hunter and Wigham Richardson, Ltd. Before sailing to the Far East, the ship, which has a service speed of 12 knots, an operating range of 10,000 miles, and can carry 420 miles of deep-sea cable, will lay cables in the Western Approaches to the British Isles. Later, the ship will proceed to her base at Singapore, from where she will help to maintain sections of the 150,000 miles of the British Commonwealth cable system, and her operational area will extend from Colombo eastwards across the Pacific to Vancouver Island.

Our photograph of the ship on trial shows that she is rigged with two masts, has a cruiser stem, and a clipper bow carrying three cable sheaves. The following are the main particulars :—Length overall, 340ft 6in ; breadth moulded, 45ft ; depth moulded to upper deck, 27ft 3in ; draught, 18ft 6in ; deadweight, 2500 tons, and gross tonnage, 3349. The ship, which has been built in accordance with Ministry of Transport regulations and to the rules of Lloyd's Register of Shipping, has two complete decks, the main and upper, a lower deck forward, and a long bridge deck. Immediately forward of the machinery space, which is arranged aft, is a transverse fuel oil bunker, and then the three cable tanks ; right forward is the cargo hold and associated 'tween deck for the stowage of buoys, grappling gear and other equipment required for cable laying and repair. Open floors are arranged under the boilers, but elsewhere there is a double bottom which is subdivided into oil fuel, fresh water and water ballast tanks. Water ballast is also carried in both the fore and aft peak tanks. Wing tanks abreast No. 3 and No. 2 cable tanks are arranged to take oil fuel, while those at No. 1 cable tank take fresh water.

The complement of the ship totals 106 officers and men, including 19 officers, 11 petty officers, 20 engine-room staff, 34 deck crew, and 19 stewards and cooks, and all are comfortably accommodated. In a house at the fore end of the bridge deck are suites for the captain, chief engineer and other senior officers, while cabins for the remaining officers are arranged on the upper deck, those for the engineer officers being arranged aft and to port in the deck house. A comfortable lounge is provided at the forward end of the house, and to port on the main deck is the dining saloon and also a small engineers' duty mess, both being served from a large pantry and galley, which is equipped with an oil-fired, three-oven range and other equipment supplied by Henry Wilson and Co., Ltd. This company has also provided the electric ranges in the engine crew's and deck crew's galleys on the upper deck aft. The petty officers and stewards have cabins forward of 'midships on the main deck, and there are separate messes for the senior and junior petty officers and the stewards. Accommodation for the crew is arranged aft on the main deck, the cabins for the deck crew being to port and those for the engine crew to starboard, with each crew having its mess arranged abreast the engine casing.

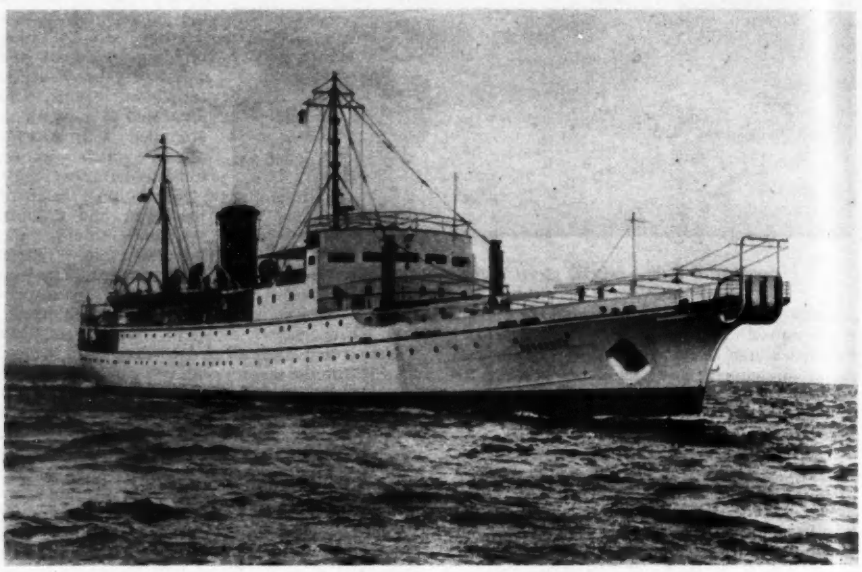
Mechanical ventilation and heating on the single-trunk system has been designed and fitted by Thermotank, Ltd., throughout the accommodation, and is capable of maintaining an equable temperature under varying climatic conditions. Deckhead and bulkhead fans are also supplied. For the convenience of the crew there is a small laundry at the aft end of the bridge deck, the equipment including an electrical washing machine, a hydro extractor, an ironing machine supplied by Thomas Bradford and Co., Ltd. The fresh and salt water systems are both operated under pressure, the installations being manufactured by Megator Pumps and Compressors, Ltd., and each consisting of two pumps delivering against a pressure of 65 lb per square inch, a pressure tank and control gear. At the aft end of the 'tween decks are the refrigerated stores and, for cooling, there is a methyl-chloride compressor with ancillary equipment, manufactured by J. and E. Hall, Ltd.

The general equipment for working the ship includes an Emerson Walker steam capstan windlass with the engine, mounted in a separate compartment on the main deck, driving two capstan heads on the upper deck through vertical shafting. Two 3-ton tubular steel derricks, carried on derrick posts, handle the buoys and other cable-laying and repairing equipment, and are operated by two Clarke Chapman steam winches having a duty of 3 tons at 55ft per minute. Emerson Walker, Ltd., has also manufactured the two warping capstans, which are fitted aft on the upper deck and can exert a pull of 4·5 tons at 75ft per minute. The ship has a semi-balanced rudder which is operated by a "telemotor" controlled Wilson-Pirrie steam steering gear, supplied by Donkin and Co., Ltd. Hand steering gear is also fitted in the compartment. Johnson and Phillips, Ltd., has been responsible for the complete installation of the two independent cable gears, dynamometers, bow sheaves, span lead sheaves, and a portable electric turning over gear for cable transfer. The gears, each of which is driven by a Sisson steam engine, are fitted with direct-acting wood and water-cooled steel band brakes and, in addition, a Heenan and Froude hydraulic brake driven through flexible couplings. An important part in the cable-laying and repair operations is played by the equipment mounted in the testing room, which is fitted with high-precision apparatus for locating faults and breaks in the cable and for testing purposes. This equipment has been supplied by H. W. Sullivan, Ltd., Muirhead and Co., Ltd., and Gambrell Brothers and Co., Ltd.

The ship is fitted with a comprehensive set of equipment for navigational purposes, including Siemens telegraphs, Kent clear-view screens, a Chernikeef log, a Brown gyro-compass, and a Barr and Stroud rangefinder ; a 5000-fathom "Lucas" sounding machine for bottom sampling and for taking temperatures, by Telegraph Construction and Maintenance Company, Ltd.; a deep-sea echo sounder, shallow water visual equipment and radar, supplied by Kelvin and Hughes (Marine), Ltd.; and a range of radio installations provided by the Marconi International Marine Communication Company, Ltd. A total of eight boats is carried in fabricated Welin-Maclachlan overframe quadrant davits operated by electric boat winches. All the boats are of mahogany and the complement consists of two 19ft working cutters, one 24ft cutter, four 27ft lifeboats, one of which is fitted with a Petter diesel engine, all built by Robsons (Boatbuilders), Ltd., and a 25ft motor launch supplied by J. and J. Harrison.

The ship is propelled by two sets of triple-expansion engines, constructed at the Neptune Engine Works of the shipbuilders, having cylinders of 15½in by 26in by 44in diameter, and a stroke of 33in. Each engine is designed to develop 1100 i.h.p. at 108 r.p.m. and drives a four-bladed manganese bronze propeller. Piston valves are fitted to the h.p. cylinders and Andrews and Cameron balanced slide valves to the i.p. and l.p. cylinders, while provision is made for the engines to run at very low speeds to suit cable laying requirements. Two single-ended, three-furnace, multi-tube, oil-fired, Scotch boilers, operating under Howden's system of forced draught, supply saturated steam at a working pressure of 220 lb per square inch. The air is heated in single-pass tubular air heaters and oil fuel is supplied to the Todd burners by a Wallsend-Howden installation. There are two circular main condensers designed to maintain a vacuum of 25½in with the sea water at 90 deg. Fah. and G. and J. Weir, Ltd., has supplied two feed pumps, each of 35,000 lb per hour capacity ; an auxiliary feed pump rated at 7500 lb per hour ; two "Monotype" air pumps ; a multi-flow feed heater, which uses exhaust steam from the auxiliaries to raise the temperature of 35,000 lb of feed water per hour to 210 deg. Fah., and an oil fuel transfer pump. Thom, Lamont and Co., Ltd., has manufactured the three steam-driven vertical duplex pumps, two having a capacity of 60 tons per hour, for the bilge, ballast services, and the third for the wash deck service, having an output of 35 tons per hour. For the circulating water there are two 1900 g.p.m. Drysdale centrifugal pumps.

An evaporating and distilling plant, built by Richardsons, Westgarth (Hartlepool), Ltd., is installed complete with Dawson and Downie circulating water, brine and fresh water pumps, and is designed to produce 30 tons of fresh water every twenty-four hours. To meet the electrical power requirements of the ship there are three 100kW, 220V d.c. generators, manufactured by Campbell and Isherwood, Ltd. These generators are placed aft of the main engine ; two, mounted on flats to port and starboard, are driven by Belliss and Morcom two-crank, compound steam engines, which are supplied with steam at boiler pressure and run at 500 r.p.m. The third generator is located between the shafts and is driven at 500 r.p.m. by a "National" four-cylinder diesel engine of 150 b.h.p., which is arranged for air starting, the air being supplied by a Hamworthy compressor driven by a Lister diesel engine. Each generator has a belt-driven auxiliary dynamo for charging a 24V 160Ah "Nife" battery.



Twin-screw cable steamship "Recorder" on trials

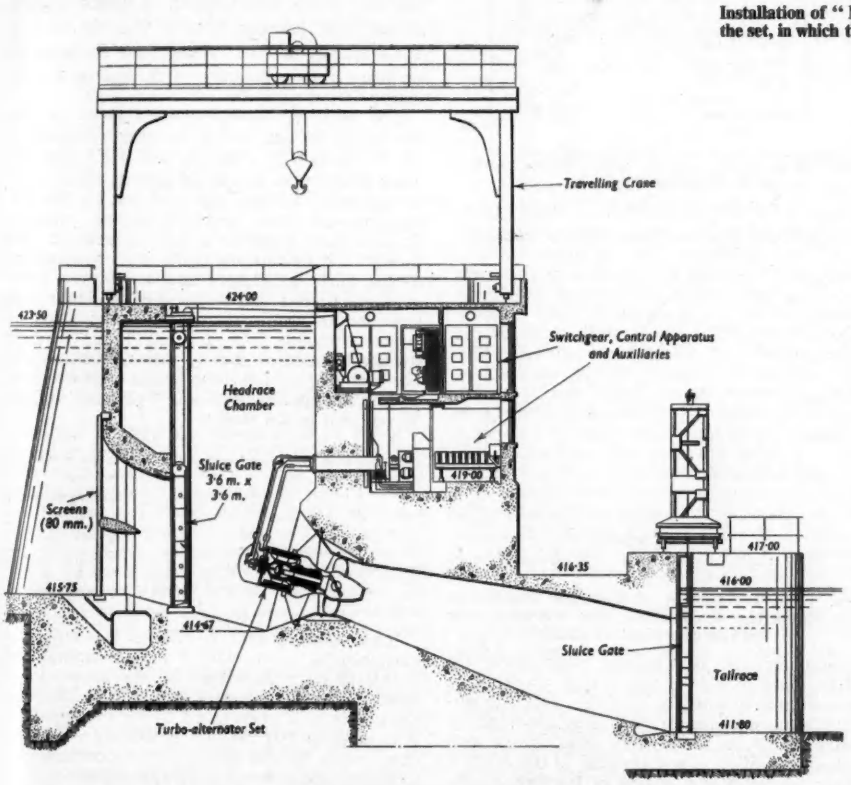
Novel Low-Head Hydro-Electric Scheme

CASTET barrage, a new French hydro-electric installation on the Gave d'Ossau River, in the Pyrénées, is considered by its designers to be the prototype of a design which will find a wide application for low-head or tidal hydro-electric schemes. The basic aim behind the evolution of the design was to economise in the civil engineering costs, which are normally heavy for low-head works. Investigation into this problem eventually led to the so-called "monobloc" turbo-generator—that is, a completely submerged turbo-alternator set, installed as one unit in the barrage. A description of the Castet scheme and of how its design was perfected, was given in *La Houille Blanche* of March/April last by H. Chamayou and J. Guimbal. The following notes are based on that article.

It is pointed out that for medium and high-head hydro-electric developments the characteristics of the site determine the design, and particularly the design of the mechanical and electrical plant, to a much greater degree than is the case with low-head schemes. The low-head schemes all basically present the same problem, which resolves itself into providing a number of sluice gates and a number of turbo-alternator sets. A range of prefabricated turbo-alternators to cover a given scale of heads—say, 1m to 15m—and of horsepowers—say, several dozen to several thousand—is thus envisaged as the ultimate possibility of the "monobloc" design. The Castet installation consists of two sets developing 1100 h.p. under a head of 7·5m, but much larger applications of the same basic design are considered to be practicable.

The accompanying illustration shows how the turbo-alternator sets at Castet are installed, each in a well in the barrage, which can be sealed by upstream and downstream sluice gates. There is a transporter crane above for lifting the sets in and out, and the electrical auxiliaries and sluice gates controls are housed in the barrage above the tail-race culverts. The power station proper has disappeared from the design; in plan the barrage consists, from the right bank to the left, of a counterforted reinforced concrete barrage wall about 50m long; two flood sluices in the former river bed, each closed by a gate 7m long and 6·5m high; the "power station" comprising two wells of the cross section shown in the illustration, each accommodating one machine set; and finally a short barrage wall joining with the rocky left bank, with the transformer (a 2000kVA, three-phase, 60/0·5kV machine) mounted on the level space behind it, which also serves as an access road.

A saving in cost of about 40 per cent over a "classical" low-head installation is claimed. The turbo-alternator sets themselves account for only about 35 per cent of the total cost in the latter case, it is pointed out, and for about 53 per cent of the total cost of a design such as at Castet; although the "monobloc" turbo-alternators are much more compact than conventional machines, the cost for a given output is said to be about the same in both cases.

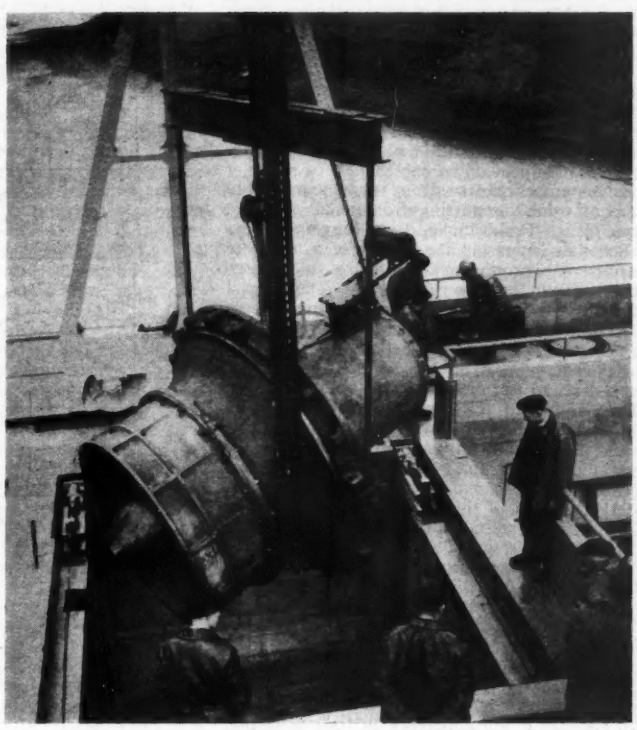


Cross section of the Castet barrage showing "Monobloc" turbo-alternator set

"Monobloc" Turbo-Alternators

Each of the two turbo-alternator sets of the Castet scheme develop 1100 h.p. under a head of 7·5m, at a speed of 254 r.p.m. and with a flow of 12·5 cumecs. The turbine is an axial-flow machine with variable-pitch blades; the guide vanes are fixed and are positioned in the annular space round the alternator, as our illustration shows. The complete set, which includes the steel lining ring and guide vanes, is shown in process of installation in the second illustration. Installation can be completed in about twelve hours.

The alternator is enclosed in the cylindrically shaped body on the upstream side of the turbine. It is a non-synchronous squirrel-cage machine, developing 810kW at 500V, 50 c/s, with a lagging power factor of 0·7, with a high overload capacity. The rotor is oil cooled, oil being circulated past the moving parts of a centrifugal pump mounted solidly with the rotor, and then, in its turn, cooled by passing along the upstream surface of the alternator-body, where heat is conducted away by the water outside. The servomotor controlling the turbine blades is placed in the interior of the rotor, and the main bearing is in the conical section between the turbine and alternator.



Installation of "Monobloc" turbo-alternator set. The upstream end of the set, in which the alternator is encased, is to the right of the illustration

The article in *La Houille Blanche* points out that once the idea of a "monobloc" turbo-alternator set had been evolved, the design necessitated first of all a considerable reduction in size of the conventional alternators (the exterior diameter has been reduced by half and the length is about the same), which, as far as the electrical calculations were concerned, was relatively simple. A more difficult question was that of preventing the leakage of water into the alternator. For this reason, it was decided to fill the alternator with oil under slight pressure, and hence to cool it by circulating the oil. The increased frictional losses due to running the rotor in oil were offset, to some extent, by the reduction in size of the rotor, and were found to be within acceptable limits. It is thought that the efficiency of alternators of this design would be about equal to that of orthodox machines, provided the friction losses caused by the oil do not exceed about 1 per cent of the output. The sets were manufactured by Neyrpic, of Grenoble, and Alsthom of Paris using the patents of M. Guimbal.

Metallurgical Topics

Size Effect in Notched-Bar Tests

THE application of the results obtained with small notched-bar test specimens to the behaviour of a large structure is a problem that has exercised design engineers ever since impact tests were introduced by Frémont and by Charpy more than fifty years ago. Since then, many researches have been directed to the investigation of size effect in notched-bar tests. The latest of these is that carried out by H. Schwartzbart and J. P. Sheehan[1] on quenched and tempered alloy steels. Most of the previous investigations did not include determinations of transition temperatures. In those which did, it was generally found that the transition temperature was higher for large specimens than for small ones. Such a change in transition temperature, if it occurs over a range which includes that of the atmosphere, may provide an explanation of many of the anomalies observed in room temperature impact value on passing from small to large specimens. For example, it was long ago recognised that increasing the breadth of a test piece results in proportional increase in energy absorbed up to a certain limit. The impact figure per square centimetre section was, at first, approximately constant. Beyond that limit, a change in type of fracture occurs, and the total energy absorbed may actually be smaller in the broad test piece than in the narrow one. This is due to the increase in the transition temperature, from below to above that of the atmosphere, with increase in breadth of the test piece. Examples of this behaviour were given in papers on the notched-bar test at the 1931 Congress of the International Association for Testing Materials and by M. Moser[2] in the discussion on notched-bar impact testing at the Manchester Association of Engineers in 1935. It is evident that size effect is dependent on temperature of test in relation to transition temperature, and that size effect in room temperature tests may differ in steels having different composition and heat-treatment. Conclusions derived from room temperature tests on mild steel are not necessarily applicable to alloy steels on account of the difference in their transition temperatures.

Schwartzbart and Sheehan investigated the behaviour of four nickel-chromium-molybdenum steels of the approximate composition, manganese 0·8, nickel 0·65, chromium 0·6, and molybdenum 0·18 per cent, with carbon 0·24, 0·33, 0·42, and 0·53 per cent respectively; also a 0·4 per cent carbon, 1 per cent chromium steel, and a similar steel containing 0·22 per cent molybdenum. They carried out tests on three sizes of specimen having dimensions in the ratio 0·5 : 1 : 1·66, 1 being the standard 10×10×55mm specimen with a 45 deg. V-notch 2mm deep. The supporting span was varied proportionally, but the root radius of the notch was 0·25mm in all specimens. Transition temperatures were determined for each class of specimen, made from each kind of steel, tempered at several temperatures between 200 deg. and 650 deg. Cent. The criterion adopted was 90 per cent brittle fracture. Typical examples are given in Figs. 1 to 4, in which transition temperatures are shown as functions of tempering temperature and specimen size. The transition temperatures of the small specimens were considerably lower than those of the standard size specimens, which were in turn generally lower than those of the large specimens, especially at high hardness. In the nickel-chromium-molybdenum steels the transition temperatures increased with carbon content. There was a maximum in the transition temperature of these steels after they had been tempered at about 350 deg. Cent.

Schwartzbart and Sheehan concluded that no consistent variation of size effect with tempering temperature or composition was observable in their data. They did, however, find that the maximum impact energy per unit fracture area (area under the notch) was relatively independent of specimen size in steels which had been tempered at from 200 deg. to 400 deg. Cent., but was dependent on specimen size in steels which had been tempered between 400 deg. and 650 deg. Cent. After this treatment (which, of course, resulted in a much higher impact value) the maximum impact energy per unit area of fracture was higher the larger the dimensions of the specimen. This is in agreement with the suggestion that in heat-treated alloy steels (in which, over a wide range, energy absorbed is proportional to width of specimen, other dimensions being unchanged) the energy absorbed by specimens of the same width which break with little deformation is proportional to the depth h below the notch (i.e. E/area of fracture is constant), whereas if they break with pronounced deformation, the energy absorbed tends towards proportionality with h^2 (i.e. E/area of fracture tends to increase with size of specimen).[3] Schwartzbart and Sheehan also found that, over the whole range of tests, maximum impact energy per unit volume decreased with increasing specimen size. This, too, agrees with previous work, for example, that of Docherty,[4] who found that if l represents linear dimensions of the test piece, E is proportional to l^m, where m varies between 2 and 3, the value approaching 3 when the test piece is sufficiently small and 2 when it is sufficiently large.

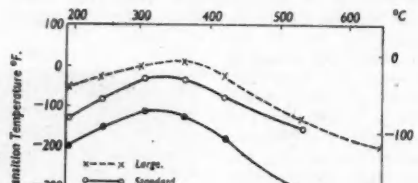


Fig. 1—0·24 per cent carbon Ni-Cr-Mo steel.

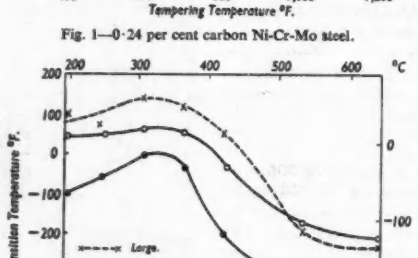


Fig. 2—0·42 per cent carbon Ni-Cr-Mo steel.

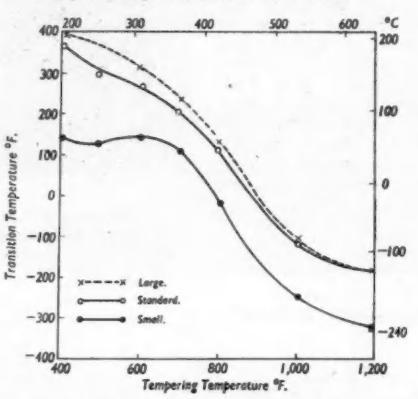


Fig. 3—0·53 per cent carbon Ni-Cr-Mo steel.

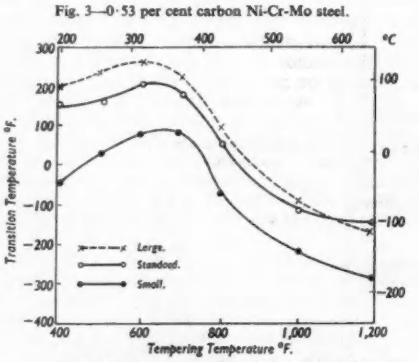


Fig. 4—0·42 per cent carbon, 0·96 per cent chromium steel.

Figs. 1 to 4—Variation of transition temperature with tempering temperature and specimen size (Schwartzbart and Sheehan)

In spite of the fact that certain guiding principles may enable a good guess to be made of size effect in different specimens of a given material, it appears that Dr. Rosenhain's conclusion,[5] in summing up the papers presented at the International Congress already referred to, that numerical results for test pieces of different form cannot be correlated by any known factor, still remains substantially true.

REFERENCES

[1] *American Society for Testing Materials*, Annual Meeting, June, 1954, Preprint 79.
[2] *Trans. Manchester Association of Engineers*, 1937–38, page 97.
[3] *Metallurgist*, 1935–36, Vol. 10, page 86.
[4] *Engineering*, 1932, Vol. 133, page 645; 1935, Vol 139, page 211.
[5] I.A.T.M., Zurich Congress Report, 1931, pages 402 and 415.

Prot Method of Fatigue Testing

As conventional fatigue tests generally involve lengthy and expensive procedure, many rapid methods of determining the fatigue limit have been employed from time to time. One such method, in which the test is carried out under a progressively increasing load, was suggested by E. Marcel Prot.[1] It was assumed that the conventional fatigue data in the region of the endurance limit could be approximately represented by a hyperbola, and that when the stress increased linearly with the number of cycles, or with time, the relation between the fracture stress S_r and the number of cycles N could be represented by another hyperbola with the same horizontal asymptote S_e. If the increase in stress per cycle is denoted by α, Prot showed that, based on the above assumptions, a linear relation should exist between S_r and $\sqrt{\alpha}$, viz., $S_r = S_e + K\sqrt{\alpha}$, and that the fatigue limit S_e could be obtained from a diagram of S_r against $\sqrt{\alpha}$ by extrapolation to $\alpha = 0$.

The value of the information given by this method of fatigue testing has been assessed by H. T. Corten, T. Dimoff and T. J. Dolan.[2] They found that S_r plotted against $\sqrt{\alpha}$ did not always give a straight line, and that the relation is expressed more generally by the equation $S_r = S_0 + K\alpha^n$, where n is not necessarily 0·5, though for ferrous materials $n = 0{\cdot}5$ appeared to give fairly satisfactory results. Various levels of starting stress that were below the endurance limit led to approximately the same value of fatigue strength. In general, lower starting stresses resulted in slightly lower values of S_0. For example, the following results were obtained on notched specimens of a 0·4 per cent carbon, 3½ per cent nickel steel :—

Endurance limit by conventional method 38,000 lb. per square inch

	n	Starting stress, lb per sq. in	
		15,000	30,000
Endurance limit by Prot method ...	0·5	39,200	42,500
	0·4	38,300	40,700
	0·318	36,900	38,800

Ingot iron, heated to 760 deg. Cent. and quenched in water, with a fatigue strength of 23,000 lb per square inch by the conventional method, showed values of 26,800 lb to 28,800 lb per square inch when tested by the Prot method. It thus seems that the Prot procedure affords an opportunity for the effects of "understressing" to appear and to result in an appreciable increase in the observed fatigue limit as compared with

that obtained by conventional methods. The method, though promising for materials with a well-defined fatigue limit, was considered to be unsuitable for non-ferrous metals. Values of only 17,000 lb to 20,500 lb per square inch were obtained with an aluminium alloy of which the fatigue strength at 10^8 cycles was 25,000 lb per square inch. It is also unreasonable to suppose that the Prot method would give reliable results in instances where environmental conditions such as corrosion, erosion or elevated temperatures contribute to the initiation of fatigue cracks. The short-time nature of the test would preclude full development of detrimental conditions that are functions of time. On the other hand, the fact that endurance limits, determined by progressive loading of notched specimens, were in close agreement with the values obtained by the conventional method indicates that, in the authors' view, the Prot method may be applicable to members of any shape, including full-sized structures.

REFERENCES

[1] *Revue de Métallurgie*, 1948, Vol. 45, page 481.
[2] *American Society for Testing Materials*, Annual Meeting, 1954, Preprint No. 69.

Relation Between Micro- and Macro-Hardness

AN advantage of the use of the diamond pyramid indenter lies in the geometrical similarity of the impressions produced, rendering the hardness number independent of the load. For an angle of impression of 136 deg,. the Vickers hardness number in kilogrammes per square millimetre is equal to $1{\cdot}8544\ (P/d^2)$. The constancy of hardness number over the usual range of load used in the Vickers machine (e.g. 10 kg to 100 kg) has been proved by long experience. To ascertain whether the same relationship holds throughout the whole range of micro and macro-hardness measurements, tests have been made by W. Schultze and L. Schimmer[1] in the Otto Wolpert " Mikro-Testor " with loads of 10 to 3000 grammes. Test blocks of steel were used with hardness about 250 and from 740 to 850. By plotting on logarithmic paper the length of the diagonal of the impression against the load employed, a straight line should be obtained in accordance with the Meyer equation, $P=ad^n$, making an angle with the abscissa whose tangent is equal to n. The measurements at all the loads used in the micro-tests fell with very little scatter on the straight

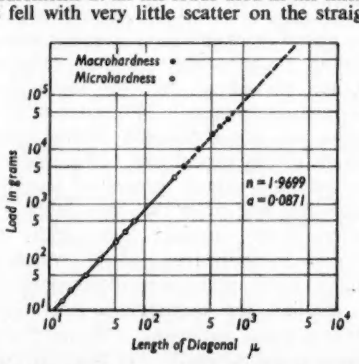


Fig. 1—Relationship between length of diagonal of impression and load for ferrite containing carbon 0·037 per cent (Schepers and Bartholome)

line and enabled the Meyer index to be calculated accurately. By extrapolation of the curve for micro-hardness, values of d corresponding to loads used in macro-hardness tests could be calculated and these showed good agreement with actual measurements. The measured hardness numbers in steels of hardness about 800 were on the average about twelve points higher than the calculated values, the greatest discrepancy being about 3 per cent. For the seven steels, the extreme values of n were 1·938 and 1·956.

Supplementary tests were made in the " Mikro-Testor " by A. Schepers and W. Bartholome[2] on the polished and etched surfaces of large crystals of ferrite and of aluminium. They were made in soft 0·037 per cent carbon steel and in pure aluminium. A typical curve is shown in Fig. 1. In the micro-hardness region, the measurements fell on a straight line which, when extrapolated to the macro-hardness region, gave values in good agreement with actual measurements. It was thus established that useful information resulted from the extrapolation into the region of macro-hardness of the straight line determined by micro-hardness measurements on ferrous materials, but it was the opinion of the authors that, owing to scatter shown by the results on aluminium, the permissibility of extrapolation must be confined to ferrous materials until more experience with non-ferrous materials was available.

REFERENCES

[1] *Archiv für das Eisenhüttenwesen*, July-August, 1954, page 337.
[2] *ibid.*, page 341.

Sigma Phase

THE sigma phase in binary and ternary alloys of high chromium content is the subject of a series of articles by A. J. Lena in successive numbers of *Metal Progress*.[1] The first part consisted of a review of sigma formation in ferritic and austenitic steels, and shows what a large number of cast and wrought alloys are capable of developing sigma. Included among them are practically all commercial chromium and chromium-nickel steels with a chromium content greater than 17 per cent, as well as the newer chromium-manganese austenitic steels. During slow cooling the sigma phase may separate at a temperature generally below (and sometimes very much below) 850 deg. Cent., according to composition, but the precipitation is sluggish and in some compositions may be evident only after long exposure to raised temperatures. Thus, in many alloys in which sigma could be formed after appropriate heat treatment, none is actually precipitated in the circumstances of their preparation and use.

The chief characteristic of the sigma phase is its high hardness (over 1000 Vickers). On this account it is friable and, in high chromium

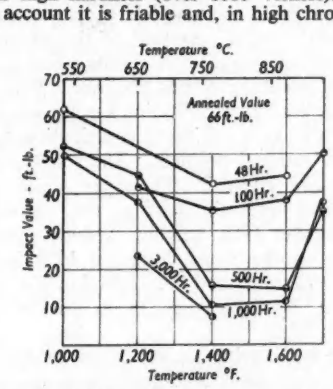


Fig. 1—Effect of time and temperature on the impact value of 25 : 20 chromium-nickel steel

steels, often shatters under the load imposed during a hardness test. When sigma is present in small amounts, the overall hardness of the steel may be only slightly affected, but its notch-sensitivity is generally greatly increased. The greatest effect of sigma is on the notched-bar impact value of the steel. Fig. 1, reproduced by Lena from a paper by G. N. Emanuel at the symposium on the Nature, Occurrence and Effects of the Sigma Phase (American Society for Testing Materials, 1951), shows the effect of time and temperature, within the sigma-formation range, on the room-temperature impact value of a 25 : 20 chromium-nickel steel. Tensile strength and hardness were only slightly affected by the 1000-hour treatment at 1400 deg. Fah. (760 deg. Cent.) but the elongation was reduced by one-third. In some compositions, however, the hardness is considerably increased, for example, in the 25 : 5 chromium-nickel steel with 0·4 per cent carbon and 2·75 per cent molybdenum, which has been used for exhaust valves when abrasion was a problem ; though hardening by precipitation of sigma is generally to be avoided because its presence may cause cracking due to thermal fatigue.

The presence of sigma tends to reduce the corrosion resistance of both ferritic and austenitic steels to a small extent, but sigma precipitation, as well as carbide precipitation, may be responsible for intergranular attack. Both are precipitated in the same temperature range, but a reagent more severely corroding than the usual copper sulphate—sulphuric acid solution (for example, 65 per cent nitric acid) is required to detect susceptibility to intergranular corrosion due to sigma rather than to carbide. The effect of sigma formation in welded components is referred to by Lena, but this is more fully discussed in a previous article by L. K. Poole[2] under the title " Sigma ; an unwanted constituent in stainless weld metal," dealing with the formation of sigma in welds, its identification and control in welding operations.

The magnitude of the effect which sigma may have on mechanical and corrosion properties of stainless steels is greatly dependent not only on the amount present but also on the particle size and distribution. When sigma separates round the grain boundaries, ductility is greatly reduced and resistance to intergranular attack is impaired. The effect of sigma on ductility and impact figure at raised temperatures is not so pronounced as at room temperature, a condition which often permits the use of sigma-containing steels for high-temperature service. Nevertheless, brittleness at room temperature remains a serious obstacle to high-temperature applications owing to the stresses to which the embrittled material must be subjected in shut-down periods. Well dispersed sigma increases short-time tensile strength at raised temperature, but has been found to decrease creep strength in long service applications. Its possible use to confer increased strength and hardness at high temperatures is limited by the other undesirable properties associated with its presence.

REFERENCES

[1] *Metal Progress*, 1954, July, page 86, August, page 94, and September, page 122.
[2] *Metal Progress*, June, 1954, page 108.

Modified Hardening Technique

A NEW method of hardening which may be applicable to cutlery blades, springs, wire for needles, and wire or strip for prestressed concrete has been developed in the Philips metallurgical laboratory, Eindhoven, and is described by E. M. H. Lips and H. van Zuilen.[1] It is a modification of the austempering method. Satisfactory results were obtained with steels which behave in such a way that, on quenching to a temperature below the nose of the time-temperature-transformation curve, the metastable austenite has a comparatively long life. In the new process, the steel is first brought into the metastable condition by quenching to a suitable temperature, and immediately worked at this temperature to its final shape. The deformation should be almost completed when the transformation of the austenite begins. The final properties are dependent on the amount of work put on the austenite before it transforms, as the temperature will be below the recrystallising temperature of the steel. After austenitising, a carbon steel wire of eutectoid composition may be drawn through dies while immersed in a suitable hot liquid and then cooled to room temperature. Wire so produced showed a creep strength of over 130 tons per square inch (as measured for prestressed concrete wire), compared with the usual figure of under 100 tons per square inch. Nickel-chromium steel strip containing carbon 0·35, nickel 4·5 and chromium 1·5 per cent showed the following properties :—

	Hardened in the conventional way	Rolled in the austenitic condition
Yield point, tons per square inch	130	178
Hardness, Rockwell C	56·5	58
Elongation, per cent	2	12
Reduction of area, per cent	5	42

This strip is said to have outstanding spring qualities. It might be expected that the treatment would induce extreme brittleness, but the ductility shown by the above figures is quite unusual for the high hardness.

The principle of this method of treatment is implicit in the work of Dartry Lewis[2] on the delayed transformation of austenite, which was carried out twenty-five years ago. The application, however, involves the development of new techniques, which, it is claimed, have been rendered practicable after some years' work in the Philips laboratories.

REFERENCES

[1] *Metal Progress*, August, 1954, page 103.
[2] *Journal of the Iron and Steel Institute*, 1929 (I), Vol. 119, page 427.

THE ENGINEER

Vol. 198 OCTOBER 29, 1954 No. 5153

LEADING ARTICLES—
Storm Surges and Flooding in the Thames ... 598
Inanimate Cussedness 599

ARTICLES—
Anglo-Norwegian Telephone Cable. (Illus.) ... 605
Armament Research and Development Establishment 581
Cable Steamship "Recorder." (Illus.) 594
"Comet" Court of Inquiry 604
Diesel Engine Users Association 581
Earlier Volumes of THE ENGINEER 610
High-Pressure High-Stroke Diaphragm Mechanism. (Illus.) 602
High-Tension Submersible Pump Set. (Illus.) 604
Hydraulic Presses. (Illus.) 606
Improved Signalling Lamp. (Illus.) 607
Interchangeable Fractional H.P. Motors. (Illus.) 607
International Exchange of Students for Technical Experience 581
International Motor Show. No. II. (Illus.)... 587
Large Diameter Aluminium Tubes in Structures. (Illus.) 584
Magnetic Coolant Separators. (Illus.) 607
Modern Developments in the Use of Large Single-Entry Centrifugal Pumps. (Illus.)... 608
National Federation of Engineers' Tool Manufacturers 581
Natural Gas Developments 581
Northam Bridge, Southampton 581
Novel Low-Head Hydro-Electric Scheme. (Illus.) 595
Shepherd's Bush Garage. (Illus.) 592
Solderless Electrical Wiring Connections. (Illus.) 606
Some Tests of Electro-Cured Concrete. (Illus.) 582
South African Oil-From-Coal Plant 586
Supersonic Delta Aircraft. (Illus.) 591
Underwater Drilling Platform. (Illus.) 603
Universal Filling Compound. (Illus.) 593
11kV Automatic Circuit Recloser. (Illus.) ... 606

AMERICAN SCENE—
Golden Jubilee of the International Electrotechnical Commission 611
Wide-Flange Beam Rolling Mill 611
Large Gas Turbine Pumping Installation. (Illus.) 611
Skyscraper Curtain Wall Erection in New York. (Illus.) 612
Maiden Flight of Four-Engined Jet Aircraft. (Illus.) 612

METALLURGICAL TOPICS—
Size Effect in Notched-Bar Tests. (Illus.) ... 596
Prot Method of Fatigue Testing 596
Relation between Micro and Macro-Hardness. (Illus.) 597
Sigma Phase. (Illus.) 597
Modified Hardening Technique 597

LETTERS TO THE EDITOR—
Off-Design Performance of Gas Turbines ... 601

LITERATURE 600
Books Received 601

OBITUARY—
Henry Nimmo, C.B.E. 599

NEWS AND NOTES—
British Patent Specifications. (Illus.) 615
Catalogues 616
Forthcoming Engagements 616
Industrial and Labour Notes 613
Launches and Trial Trips 616
Notes and Memoranda 614
Personal and Business 614

STORM SURGES AND FLOODING IN THE THAMES

There is promise of more than usual interest in the various papers and lectures which are to be given during this winter's session at the Institution of Civil Engineers. Last week we drew attention to the first meeting of the session when the new subject of radioactive wastes and their treatment was discussed. The second meeting, held on October 19th, was in its way equally informative. When the Waverley committee was asked to report on the effects of the 1953 storm surge, one of the most urgent problems it had to face was that of recommending measures to prevent flooding in the Thames estuary, particularly in the built-up areas of the docks and of riparian London. The extensive development existing along the banks of the Thames and the working of the docks made it impossible to recommend a general heightening of the river walls, which would have obviously been too costly and intricate to be a practicable solution. The position was aggravated by a controversy over the effects of the general heightening of the river embankments further downstream, which, it was contended, would prevent any water spilling over the embankments should a surge occur again and hence increase even further the river levels in the London area. The committee was fortunate, however, in having at its disposal a tidal model of the River Thames. When the Hydraulics Research Station—the youngest establishment of the D.S.I.R.—was formed, its first programme of works included the construction of tidal models of the Thames, and of the development of a new form of tide generator for use with such models. The tide generator (see THE ENGINEER, July 25, 1952) can reproduce tides following any given slopes of tidal curve, the desired tidal sequence being plotted on a master chart; thus the reproduction of surges is possible in the model. The existence of the model, equipped with the new tide generator, made possible a rapid appraisal of the situation, and yielded quantitative results which could not otherwise have been obtained. Thus the Hydraulics Research Station has already been able to make a significant contribution to an urgent national problem. The results of its work are given in the paper which was presented and discussed at the "Civil's" on October 19th, namely, "Model Experiments on the Storm Surge of 1953 in the Thames Estuary and the Reduction of Future Surges," by F. H. Allen, W. A. Price and Sir Claude Inglis.

The engineering aspects of the 1953 storm surge have been recorded comprehensively in this journal, in various articles which have been published from time to time since the surge was experienced along the east coast. There is, therefore, no need to outline the background of events which led to the series of experiments described in the paper, but one or two of the principal results may be briefly quoted. The effect of an upland river flood, coinciding with a surge of the same magnitude as that experienced in 1953, was investigated and tests were also made to determine the effect of spill over the embankments in the lower part of the estuary, and the combined effects of spill over and breaches in the embankments. The results of these experiments showed that, with an upland flood of 20,000 cusecs combined with the 1953 surge, the maximum water level at London Bridge would have been 9in higher. With conditions as for the 1953 surge, the effect of spilling over the downstream embankments reduced the level at London Bridge by less than 1in, and the combined effect of the breaches and spilling was considered to be a lowering of 3in or 4in at London Bridge. Further experiments were carried out with a "1½ft higher surge"; they indicated an increase in level of 20in at London Bridge with a low river flow, and an increase of 27½in with a 20,000 cusecs upland flood, measured above the top level of "the 1953 storm surge without spill or breaches." With these new conditions, spill over the embankments (reproduced as they were in January, 1953) reduced the peak level by 15½in. Three-quarters of the flooding which occurred in the 1953 surge, it was noted, took place through breaches in the embankments, and occurred principally after high water and thus did not affect the maximum upstream levels. The effect of a surge reducing barrage was then investigated, which, it was postulated, would consist of a multi-gate structure operated in conjunction with a surge forecasting system, so that the river channel could be closed, or partially closed, at a given time before high water. A site at Long Reach was chosen for the first tests, and the paper includes graphs showing the effect of the barrage on the water levels upstream and downstream, with different degrees of closure and times of closure relative to high water; the results indicated a large measure of control over high-water levels in London with, for instance, a decrease of 18ft 6in at London Bridge, under 1953 conditions, with 100 per cent closure four hours before high water. Since the paper was written further tests have been carried out on an alternative site for the surge reducing barrage at Woolwich, and with a "3ft higher surge" and an upland flow of 40,000 cusecs which are considered as extreme conditions.

The engineering works involved in protecting coastal lands from the sea and from storm surges have been handicapped by a lack of basic knowledge; that fact has been made abundantly clear from the views expressed since the 1953 disaster. But here at least, is one aspect of the problem which has proved amenable to a scientific analysis, yielding quantitative results sufficiently detailed to still all but the most closely reasoned controversy. The accuracy of the results was not challenged during the discussion of the papers, but rather was commended and found generally acceptable, which has not been the case with some earlier work carried out with tidal models. As to the care and skill which went into the work, perhaps an idea can be given by quoting the accuracy—$\pm 0{\cdot}01$in—with which rapidly fluctuating water levels were measured in the model. The relatively minor effect on London of spilling water into low-lying areas downstream was demonstrated and the much more effective control given by a surge-reducing barrage was clearly shown. The barrage has, however, been investigated in principle rather than in detail, and is to be considered further, we understand, by the Thames Technical Panel, a body formed as a result of the Waverley Committee's report. When the surge-reducing barrage comes to be considered further, however, a fifty-year-old controversy will doubtless be revived. We refer to the proposals made for the construction of a barrage across the lower part of the Thames, intended to transform it upstream into a fresh water lake with a constant water level, for which many advantages have been claimed. A public inquiry into the merits of this scheme was to have been held in

1938, but was vetoed for reasons of national defence. The surge reducing barrage proposed in the paper we have been discussing is, of course, " quite different in design, operation and purpose " as the paper states. But doubtless—since a Thames barrage would give protection from storm surges—exponents of the older scheme will consider that an appraisal of the relative merits of both proposals should be fully made before any final decision for or against a barrage is reached. It seems very probable that model tests would again give valuable information in unravelling the respective merits and drawbacks of these two schemes.

INANIMATE CUSSEDNESS

Engineers, we suppose, having had a scientific training, ought to regard inanimate nature as neutral in their affairs rather than as a benevolent or hostile influence. For how can inanimate matter, having neither a soul nor a brain, and certainly no bowels of mercy, exhibit any quality more bothersome than a neutral, unhelpful inertia ? Yet we confess to finding it difficult to attain so refined a degree of scientific detachment. "Contrariwise," as Tweedledee said, "if it was so it might be ; and if it were so it would be ; but as it isn't, it aint." We incline much more to the opinion of a writer (whose name at the moment escapes us) about " the total depravity of inanimate things." The scientists may be right ; no doubt explanations can always be found for everything. But how comes it about that it seems invariably to be the last nut to be screwed on, not the first, that gets on the cross and strips the thread ? That the one drop of oil that falls on a blue-print so often chooses to cover up a dimension ? That a cutter which has demanded very careful setting decides so often to break not as the job is begun but just a few seconds before it is finished ? Again, is it not odd—to say the least about it —that the particular drill size urgently needed is so often the one size that is out of stock ? Or that more probably than not, just when a production line has been set up and is working smoothly, a pressing demand for a set of spares arises, requiring for their manufacture certain of the very machines on the line ? Then there is that inanimate imp, well known to all engineers, who removes from its place the tool one has but just now set down ; and who can only be induced to return it—usually to the very place where one first looked for it !—when in desperation some far less suitable implement has been chosen as a substitute. That imp clearly delights in convincing mankind, against every such beneficent precept as " If at first you don't succeed . . ." that the best way to find something is to cease looking for it. Is not this evidence enough of depravity and of alliance with the Devil ?

Nor are the graceless transgressions of the inanimate only to be experienced in the workshop. How peculiarly often erectors find that the heavy unwieldy 20ft long item of plant fails by a bare one-quarter of an inch to be manœuvrable in a restricted space. What a wicked invitation is thus offered to profanity ! Then, again there is the object which proves so immensely troublesome to load upon a vehicle that particular measures are prepared for its unloading ; whereat, to the embarrassment of all (an inanimate imp, no doubt doubled up with mirth the while) it practically unloads itself ! The same kind of maladjusted humour is to be observed elsewhere. Nobody really complains about depravity when the Devil sets himself whole-heartedly in action. It is after all just what is to be expected of him. If at the very instant of the " great man's " arrival something really disastrous were to happen, such as, for instance, the disappearance of a turbine rotor through the powerhouse wall, it would all be very exciting. Indeed it would make the " great man " sit up and take notice. As likely as not he would himself be involved in doing something about it. But does anything like that happen ? Of course, not ! Some little fiddling thing goes wrong instead. A joint starts leaking, spraying oil finely over the specially polished floor, a loosened nut, which no one can find, starts chattering, a warning device develops a defect, crying " Wolf ! Wolf ! " when in fact there are no wolves about, or a fuse decides to blow for no other reason than that it feels like it. Of course, it is also true—the scientific purists who explain all upon the laws of chance will no doubt point it out—that the very opposite sometimes happens. It may be that a machine which under test has given constant trouble performs to perfection as soon as the customer comes into the shop. Yet how embarrassing is the consequence ! For what is now to be done ? Shall the machine be despatched at once, as the customer expects, in the pious, but hardly probable hope, that defects revealed in earlier tests have really cured themselves ? If not, how is the delay to be explained to an eager and impatient customer who has seen for himself the " excellence " of the job ? Ye gods ! What opportunities there are for gremlin fun !

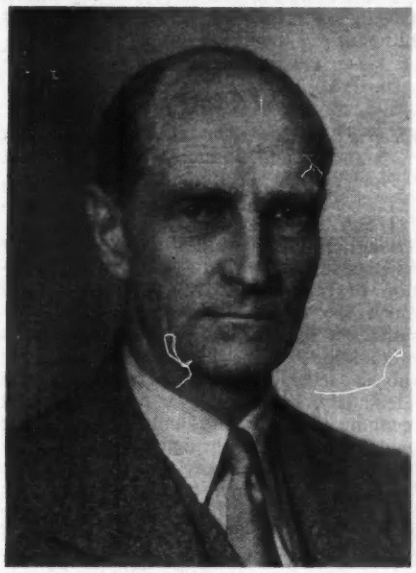
It is when things are going really well that the experienced engineer becomes most cautious. For inanimate nature is predictable only in these terms : it likes to strike hardest when the job is nearly done, for then the blow will be most cruel ; it likes by preference to strike when everything is going well, for then the blow will be least expected. Unquestionably there is a guardian angel who looks after engineers' affairs. But in guarding our lives, our limbs and our professional reputations he cannot always give attention to inanimate imps that slip past him. Inanimate nature is not neutral. Milton had no doubts about it. He refers to " Belldam Nature." But that, at least in reference to inanimate nature is, we think, far too strong. Engineers, through daily familiarity with the inanimate, have grown more tolerant. Paradoxically they have gained almost an affection for its impishness. " Then the bowsprit got mixed with the rudder sometimes." There is, of course, no help for such a misfortune. No one is to blame. It is just the kind of trick inanimate nature *will* play during the course of an expedition so important as the hunting of a Snark. But though the inanimate appears hostile, it is not really wicked. It just has a mischievous unpredictable inconsistency. We engineers have a better term for it than had Milton. We just call it cussed !

Obituary

HENRY NIMMO, C.B.E.

It is with regret that we have to record the death at Matching Green, Essex, on Monday, October 25th, of Mr. Henry Nimmo, who was chairman of the Southern Electricity Board and was formerly an Electricity Commissioner.

Henry Nimmo was born at Cambusnethan, Lanarkshire, in 1885, and was educated at Airdrie Academy and Coatbridge Technical School. His practical training was acquired first with Messrs. Shearn and Pettigrew, of Wishaw, and then with Bruce Peebles and Co., Ltd., of Edinburgh. In 1906 he joined the British Westinghouse Company as an erection engineer and a year later he was appointed chief electrical engineer to the



Henry Nimmo

Oakbank Oil Company, Winchburgh. After two years in that position he went to Burma as chief electrical engineer of the Irrawaddy Flotilla Company, Rangoon. His association with the electricity supply industry began in 1912, when he became assistant engineer to the Rangoon Electric Tramway and Supply Company, and in 1914 he was appointed officiating chief electrical engineer in the Public Works Department of the Government of Burma.

During the first world war Mr. Nimmo served with the London Electrical Engineers, R.E. (T.). On returning to Burma after the war he became chief electrical engineer and electrical inspector to the Burmese Government, and he was responsible for carrying out the hydro-electric survey of that country. His service in Burma ended in 1929, when he returned to England with the appointment of chief engineering inspector to the Electricity Commissioners, at a time when the British grid system was coming into being. In 1945 he was appointed an Electricity Commissioner. During the war he also acted as electrical power adviser to the War Office.

When the electricity supply industry was nationalised in 1948, Mr. Nimmo became chairman of the newly created Southern Electricity Board and a part-time member of the British Electricity Authority. His interests and his services to the electrical industry were many sided. He was a member of council of the Institution of Electrical Engineers and served for three years as

honorary treasurer. He was also a member of council of the Electrical Research Association and of the British Electrical Power Convention and a member of the administrative council of C.I.G.R.E. (Conférence Internationale des Grands Reseaux Electriques). He was a past-chairman of the British Electrical Development Association, past-chairman of the Isle of Man Hydro-Electric Commission, and a past-president of the Association of Supervising Electrical Engineers. Mr. Nimmo's attitude towards the status of the engineer in public affairs was well exemplified by his active interest in the Engineers' Guild and, when he died, he had just completed two years in office as the president of the Guild. He was a member of the three engineering Institutions—the Civil, Mechanical and Electrical Engineers.

A Memorial Service will be held at The Queen's Chapel of the Savoy, Savoy Street, W.C.2, on Thursday, November 4th, at 12 noon.

Literature

Electric Power Transmission. By JOHN ZABORSKY and JOSEPH W. RITTENHOUSE. New York: The Ronald Press Company, 15, East 26th Street, New York 10, N.Y., U.S.A. Price, 12 dollars 50 cents.

THE criterion of a good textbook, no matter whether it is intended to be used for instruction or for reference purposes, is not so much the technical data it contains, but rather the thought that has been put into its preparation. The technical aspects of the subject must, of course, be dealt with adequately, but this alone does not recommend the book unless the author guides the reader through the subject in logical steps and finally provides sufficient information to enable him to make further studies on his own. The authors of *Electric Power Transmission* have amply fulfilled all the above requirements and the book can be classed among the other excellent volumes that have been written on the subject. The main claim for the use of this book in preference to previous publications is that it is completely up to date and provides the reader with information and references on certain aspects of power transmission which have not previously appeared in book form. The book, which has been written primarily for the use of advanced engineering students, will be useful to practising engineers who have a thorough grounding in the subject. A number of illustrative examples have been worked out in detail, in order to help those readers who are perhaps a little rusty in their mathematical knowledge. In each chapter a very extensive list of references is given, and these have been put at the end of the section concerned instead of at the end of the chapter. This is a very useful innovation. The majority of these references are, of course, American, but certain foreign publications have been included.

The authors are to be congratulated on beginning the book with an excellent introduction which discusses the basic structure of power systems in the United States, thus introducing the reader to the subject of distribution and transmission before starting on the theoretical aspects of electrical power transmission. This should be of assistance to readers not already familiar with the subject. The first three chapters deal very fully with the theoretical basis on which the characteristics of overhead electrical transmission lines are calculated, namely, inductive reactance, resistance, skin effect and capacitive reactance, and brings the subject up to date with modern practice. Chapter 4 on corona losses deals fully with the subject and gives details of the results of recent investigations that have been carried out on very high voltages, both in America and Europe. Chapter 5 deals adequately with underground cables for transmission purposes and gives a good deal of interesting information on the methods used in calculating temperature rise and heat dissipation in cable duct systems, which has not previously been published in book form.

In Chapter 6 the authors tend to follow telephone rather than power engineering practice in developing the classical theory of long transmission lines with distributed constants. The equations are first developed in the usual hyperbolic form and then converted to the exponential form associated with incident and reflected waves. Due to this method of approach they designate $\sqrt{ZY}$ as the "propagation constant" instead of using the power engineer's normal term of "attenuation constant" or "hyperbolic angle of the line." This innovation has a good deal to be said for it since it helps the reader to grasp the fundamental principles of electrical transmission problems, whether for communication purposes at multiple frequencies or for electric power transmission at a single frequency. They also use the telephone engineer's term "characteristic impedance" for $\sqrt{Z/Y}$ instead of "surge impedance" or "natural impedance." These latter terms are almost universally employed by power engineers. It is considered that this change of term is unfortunate since it may lead to some confusion among engineers who refer to the normal constants of the line as its characteristics. This is only a minor criticism, however, of an interesting and instructive chapter.

Chapters 7 and 8, which occupy some 30 per cent of the book, deal very fully with the theory of steady state operation of transmission lines operating at a single frequency, the usual equation based on the general line constant A, B, C, D, being developed in detail. One of the more interesting sections of this chapter is the use of these general line constants in the construction of line charts and circle diagrams. The equations of these diagrams, although based on the classical work of Evans and Sels and other writers between 1921 and 1926, are expressed in a different form from that usually adopted in previous books, and this has brought the subject completely up to date. Illustrative examples have been worked out in detail and the associated diagrams constructed, so it is a simple matter for the reader to appreciate the advantages obtained from this improved method of approach. In connection with these charts, it is considered unfortunate that the authors have expressed the constant D in the form $D\underline{/\delta}$ with the result that the angle between the voltages on a system is expressed as $\underline{/\theta}$. In the majority of modern textbooks the angle δ has been accepted as representing the angle between voltages at the two ends of a circuit. It is felt that this change in symbol may therefore lead to some confusion. In this connection, it is interesting to note that the universal circle diagram printed in America, a copy of which is given in the book, uses the angle $(\beta \pm \delta)$ and not $(\beta \pm \theta)$, as used by the authors. In these chapters, the authors make no excuse for going into the complexities of the problem in great detail and wisely point out that a thorough understanding of the theoretical side of the subject is essential before the solution of problems either by approximate methods, examples of which are given in the text, or by the use of network analysers, is attempted.

Chapter 9 deals with the general question of voltage regulation on transmission lines and distribution systems, and describes in some detail the usual methods used. It brings the subject up to date with modern practice by dealing with the use of series capacitors. The last two chapters, 10 and 11, deal with the important question of load frequency regulation and power system economy. A great deal has been written on the two subjects, both in the technical press and in scientific journals, and it is very useful to have available in book form the general trend of development in these two fields.

Very little has been written in English books on the question of governor action on transmission systems. This is an important subject and is dealt with fairly fully in Chapter 10. The first part of Chapter 11 deals with the economic loading of plant on transmission systems. The technique of loading various steam-driven units in accordance with their incremental heat rates, which has been fully developed in the United States, is described. The latter part of this chapter deals fully with the rather controversial question of economic expansion of plant and the application of the probability theory to plant outages.

The book concludes with two appendices. Appendix I contains a large number of useful tables dealing with the characteristics of American overhead line conductors when operating at 25, 50 and 60 cycles, and of American cables operating at 60 cycles. Appendix II is a valuable addition to the book, since it deals with the various methods used for solving simultaneous linear equations. The book is therefore a welcome addition to the quite extensive literature on the subject and can be recommended to both students and practising engineers interested in the complex problems associated with the steady state operation of electrical power transmission systems.

Raw Materials for Electric Cables. By A. KING and V. H. WENTWORTH. London: Ernest Benn, Ltd., Bouverie House, Fleet Street, E.C.4. Price 42s.

THIS volume was originally published as a series of articles in the *Electrical Journal*, but, prior to publication in book form, all the information has been brought up to date and amplified where necessary. The authors are practical technicians employed by the largest cable manufacturing organisation in the British Empire, and the book is based on their wide experience, coupled with the large volume of research and processing data acquired during their many years spent in the cable manufacturing industry. The wide range of detailed information provided relating to the material sources, chemical, mechanical and physical characteristics of, and the industrial processes associated with, the extensive range of raw materials used in the manufacture of modern cables is indicated by the following chapters:—Copper, paper, insulating oils and compounds, black varnished cambric, rubber, synthetic rubber and thermoplastics, lead, aluminium, steel, textiles, lacquers, &c. Lead, after more than half a century as the principal cable sheathing material at last faces a serious competitor—aluminium—and this comparative newcomer among the industrial base metals is considered fully and factually in Chapter 13.

Numerous references to British Standards are made throughout the book and definitions of cable makers' terminology are provided, which are helpful to the reader. The authors have shown particular care in the accuracy and choice of the information included in the

book and therefore it is rather disappointing to find on page 50 a vague and ill-informed criticism of Type Test Specifications, which are to cable users an assurance that the raw materials used and processing techniques adopted by the cable maker are sound in relation to the service conditions under which the cables (and their associated accessories) will have to operate throughout the long life normally anticipated for this equipment. As far as we are aware, there is no other book published in the world which considers in detail the "Raw Materials for Electric Cables," and it is an excellent book for all who have a close interest in the manufacture or utilisation of electric cables.

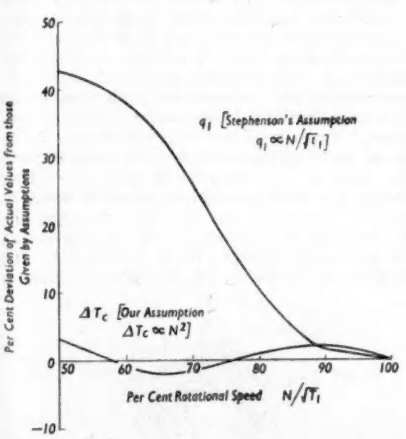
Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

OFF-DESIGN PERFORMANCE OF GAS TURBINES

SIR,—We were very interested to see in your issue of July 16th an article discussing how our assessment of the part-load performance of various possible gas turbine engines* has withstood the tests of the past six years. Our pleasure increased on finding that the article came from the pen of our friend and former colleague, Mr. J. M. Stephenson, but disappointment and disillusionment were to follow, for instead of the mature and reasoned criticism which Mr. Stephenson is well qualified to give, we found a hasty, almost precipitate, choice of words and arguments and a tendency to concentrate upon features which are not pertinent to the subject of the 1948 paper.

For example, Mr. Stephenson's comments are largely concerned with the aircraft gas turbine, detailed discussion of which was expressly



Characteristics of modern aero-engine compressor

omitted from our paper to the Institution of Mechanical Engineers, since much was already known and published on this topic. Mr. Stephenson must remember that the performance of a double-compound jet engine, in discussion of which he fills out his paragraph on turbine characteristics, forms the subject of an earlier report of ours, nowadays available as R. and M. 2645 of the Aeronautical Research Council, Ministry of Supply.

It is, however, the inaccuracies introduced by Mr. Stephenson's rather "slipshod" reasoning which cause us most disquietude. For instance, he mars an otherwise fair and reasonable description of his idea of "variable intercooling" by stating that the more normal method of intercooling, to which we confined ourselves, "implies an effectively infinite mass flow of coolant," whereas it really implies nothing more than a flow adequate for the full load condition.

Of more importance, since it seems to be the point on which the majority of Mr. Stephenson's criticisms are focused, is the fallacy by which he seeks to discredit our rule-of-thumb assumption that in a compressor the overall temperature rise ΔT_c can often be considered proportional to the square of the rotational speed N. We should emphasise, since Mr. Stephenson does not, that the assumption is only used in our paper as an aid to the understanding of results found by more detailed calculation. In a flurry of mathematics, however, our reviewer seeks to demonstrate the limited application of the rule, but in so doing he uses an assumption of much more questionable validity. For into the hypnosis induced by a series of differential equations he inserts what he calls the common assumption that "over the region of interest q_1 varies as $N/\sqrt{T_1}$," where

$$q_1 = Q\sqrt{T_1}/P_1 = \text{inlet mass flow coefficient.}$$

and

Q = air mass flow.
T_1 = inlet air temperature.
P_1 = inlet air pressure.

He then proceeds to find a pressure ratio at which ΔT_1 may vary as N^2, but fails to recognise that he has simply found a condition where the two assumptions are not incompatible, without having proved anything about the validity of either. Instead, he states categorically that "it is thus only when the compression ratio of a compressor-turbine set is between 3 and 4, say, and the turbine is choked, that the values of $\Delta T_c/N^2$ for the compressor and turbine can be considered constant." He does not think to doubt the assumption he has himself made, yet a glance at, say, the characteristics of the compressors of the Rolls-Royce "RM60" marine engine, published in your issue of November 13, 1953, to which he refers, would have shown him that the assumption is far less exact than the $\Delta T_c \propto N^2$ rule he seeks to question. Along the engine running line, which must surely be the "region of interest," there is up to 25 per cent deviation from his assumption of q_1 proportional to $N/\sqrt{T_1}$, but only about 3 per cent deviation from our rule-of-thumb.

Since Mr. Stephenson suggests that the $\Delta T_c \propto N^2$ relationship is outmoded in modern compressor design, we have also looked at the characteristics of a modern aero-engine axial compressor of high design pressure ratio and along the engine operating line find a similar disparity between Mr. Stephenson's assumptions and reality, as the accompanying figure shows. A different engine operating line, such as would be obtained if the compressor were used in some entirely different application, would result in some modification in the curves we have plotted, but it is impossible to reduce the error implied by Mr. Stephenson's assumption by more than a third and then only at the expense of operating at very poor compressor efficiencies at the lower rotational speeds.

It is true that in the conventional fixed geometry turbo-jet engine the range of non-dimensional rotational speed which is of greatest interest is possibly within ± 10 per cent of the design value and that within this range there is little to choose between the two assumptions under discussion. We feel, however, that the phenomena discussed by Mr. Stephenson in his concluding paragraph can be more satisfactorily described in the following manner. In general, the maximum rotational speed of such a jet engine can only be expected to coincide with maximum turbine operating temperature at one condition of engine entry temperature. To spread this region of coincidence over a range of entry temperature—that is, of altitude and flight speed conditions—it is necessary for a relationship of the type $\Delta T_c \propto N^2$ to apply to the compressor along its operating line. (This is simply because the compressor temperature rise is proportional to the temperature drop in the turbine driving it and this, in turn, is held as a fixed faction of the turbine inlet temperature by the existence of a choked air flow downstream of the turbine, for instance, in the propelling nozzle.) Any departure from the $\Delta T_c \propto N^2$ relationship will result in variation of turbine entry temperature at constant rotational speed, when the engine inlet temperature is varied. In general, it is safe to predict the form this variation will take in a particular case only after a careful study of the characteristics of the components involved has been made.

D. H. MALLINSON and W. G. E. LEWIS
National Gas Turbine Establishment,
September 27th.

SIR,—Mallinson and Lewis appear to accept my point that, unless $\Delta T/N^2$ is constant, the design values of turbine entry temperature and rotational speed only coincide for one ambient temperature. A burning question which confronts design and control engineers to-day is: which way will either go when the ambient temperature changes? Obviously, "a careful study" has to be made for each particular case (and I have made many such); but I tried to show that, with certain approximations, there is a general trend. The reliability of the assumptions must await further analysis: it is a pity your correspondents have not been permitted to develop further their studies of this important subject. I hold fast to my argument about intercooling. If the thermal ratio of a cooler is to be constant for all air flows (without control of the coolant flow), then it must always be 100 per cent which does imply a very large cooler.

J. M. STEPHENSON
Danbury, Connecticut, October 15th.

[It is true, as Mr. Stephenson says, that Messrs. Mallinson and Lewis are no longer directly engaged in the study of these problems. But Mr. Stephenson is in error in his suggesting that they have not been permitted to continue to work upon them.—ED. THE E.]

Books Received

Man and Energy. By A. R. Ubbelohde. London: Hutchinson's Scientific and Technical Publications, Stratford Place, W.1. Price 18s.

Rubber, Natural and Synthetic. By H. J. Stern. London: Maclaren and Sons, Ltd., Stafford House, Norfolk Street, W.C.2. Price 75s.

Elements of Mechanism. By V. L. Doughtie and W. H. James. London: Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 48s.

The Scientific Basis of Road Design. By F. L. D. Wooltorton. London: Edward Arnold (Publishers), Ltd., 41, Maddox Street, W.1. Price 60s.

Everybody's Book of Electricity. Revised edition. By R. Barnard Way. London: Percival Marshall and Co., Ltd., 19 and 20, Noel Street, W.1. Price 3s. 6d.

Electro-Plating and Corrosion Prevention. Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 21s.

Hygrometric Data for Air Conditioning Calculations, together with Supplementary Data for Temperatures up to 300 Deg. Fah. London: The Institution of Heating and Ventilating Engineers, 49, Cadogan Square, S.W.1. Price 10s.

Rutherford by Those Who New Him. Being the Collection of the First Five Rutherford Lectures of the Physical Society. Reprinted by the Physical Society, 1, Lowther Gardens, London, S.W.7. Price to Members, 5s.; Non-Members, 8s. 6d.

The Physical Society: Reports on Progress in Physics. Volume XVII. Executive Editor, A. C. Stickland. London: The Physical Society, 1, Lowther Gardens, Prince Consort Road, S.W.7. Price to Non-Fellows, 50s.; to Fellows, 27s. 6d.

Handbook of Aeronautics. No. 2: Component Design. Fourth edition. Published under the authority of the Council of the Royal Aeronautical Society by Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 30s.

* *Proc. I.Mech.E.*, Vol. 159, page 198, November, 1948.

High-Pressure High-Stroke Diaphragm Mechanism

By W. MULLER

A new type of flexible diaphragm mechanism is described which is suitable for operation at high differential pressure and at the same time allows considerable axial movement. Test and development work has been done under the sponsorship of the Ministry of Supply.

FLEXIBLE diaphragms enable a complete seal to be provided between two chambers and at the same time allow axial movement (e.g. for control purposes) to be transmitted from one chamber into the other. In many systems the movement is imparted to the movable members through a differential pressure acting on the diaphragm which then works as a piston servomotor.

Compared with a piston, a diaphragm offers the advantages of low frictional resistance to the movement, complete absence of leakage and less precise machining for its manufacture. These properties are extremely desirable for many applications as, for instance, in a control system. When a piston is used to operate a valve, the very restricted clearance between the piston and the bore necessary to keep the leakage within reasonable limits is likely to be a source of trouble as it makes the system sensitive to dirt or to any mechanical or thermal distortion of the casing.

Diaphragms of conventional design have been unable to replace, on a larger scale, pistons in similar control systems because of the small axial movement admissible, the length of this movement being the smaller the higher the differential pressure across the diaphragm. The possibility of increasing the small stroke of the diaphragm by mechanical means is generally not attractive in view of the complications involved, such as additional friction and back lash.

A solution to this problem is presented by the diaphragm mechanism shown in the illustrations. It is suitable for operation at high differential pressure and also allows large axial movements, thus combining the advantages of a piston with those of a conventional flexible diaphragm.

Longitudinal sections of the diaphragm mechanism are shown in Fig. 1*a* (mechanism in initial position), Fig. 1*b* (after one-third stroke), and Fig. 1*c* (final position, after full stroke). A plan view is shown in Fig. 1*d*, while Fig. 2 gives a perspective view of the push rod and guide.

The diaphragm 1 is made of some suitable flexible material and is moulded in the frustro-conical shape as shown in Fig. 1. Its plane periphery is tightly secured between corresponding faces of the casing 2 and the upper cover 3, the inner face of which corresponds with some clearance to the profile of the diaphragm 1. The lower face of the plane central section of the diaphragm is in loose contact with the upper surface of the cylindrical section 4 of the push rod 5, which is axially movable in a cylindrical bore of the lower cover 6. Integral with the push rod 5 is a cruciform support 7 (Fig. 2), which slides in four parallel grooves 8 of the casing 2 (Fig. 1*d*). The upper face of the support 7 is conical, with an inclination equal to that of the conical section of the diaphragm 1, and a set of concentric rings 9 of equal axial lengths and with well-rounded edges occupy the space between the support 7 and the diaphragm 1. Ample radial clearances are provided between the rings and also between the inner and outer rings and their corresponding guiding faces, i.e. the section 4 of the push rod 5 and the cylindrical section of the casing 2 respectively. The upper faces 10 of the lower section of the casing 2, into which the grooves 8 are machined, are also conical like the support 7, the slope, however, being inverse to that of the support. The push rod 5 is axially guided by the bore of the lower cover 6 and is kept in the initial position by the spring 11.

To operate the mechanism, suitable fluid under pressure is admitted through the inlet of cover 3 into the narrow space above the diaphragm 1. Obviously, the diaphragm is fully supported against the fluid pressure by the upper portion 4 of the push rod 5 and by the upper edges of the rings 9, which transmit the pressure to the support 7 and thus to the push rod. As soon as the fluid pressure is sufficiently high to overcome the spring load and the resistance of the member to be moved (such as a valve or switch) the push rod 5 moves downwards.

During this axial movement of the push rod 5 the support 7 slides in the grooves 8, and the rings 9 are successively transferred from the support 7 to the stationary conical faces 10. Fig. 1*b* shows a position where the two outer rings rest on these faces 10, while the six inner rings are still carried upon the shoulders of the support 7. In Fig. 1*c* the mechanism has reached the end of its stroke and the rings 9 are now all supported by the stationary faces 10 after symmetric reversal of the diaphragm 1. The stroke of the push rod 4 is limited by contact of the diaphragm with a stop face in the cover 3 and by seating of the support 7 upon the upper face of the casing 6.

It will be easily understood that the diaphragm 1 is, at any position of the push rod 4, safely supported against the acting fluid pressure. It is also clear that the diaphragm is subjected merely to a bending process which is strictly controlled and which can be predetermined so that no premature fatigue of the material will occur. Radial stresses are exerted only in so far as the diaphragm bridges the gaps between the edges of the supporting rings 9. These stresses can be kept within reasonable limits by varying, according to the fluid pressure, the number and the thickness of the rings as well as the clearance between them. Obviously, the support improves if the number of rings is

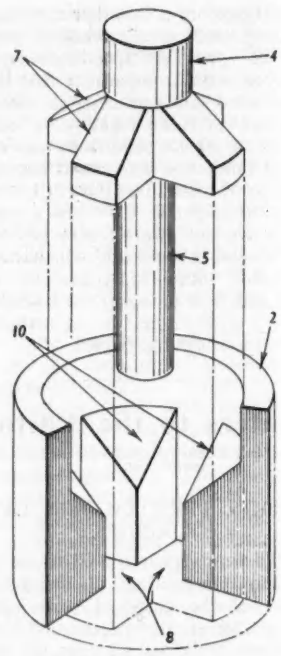


Fig. 2—Push rod and guide

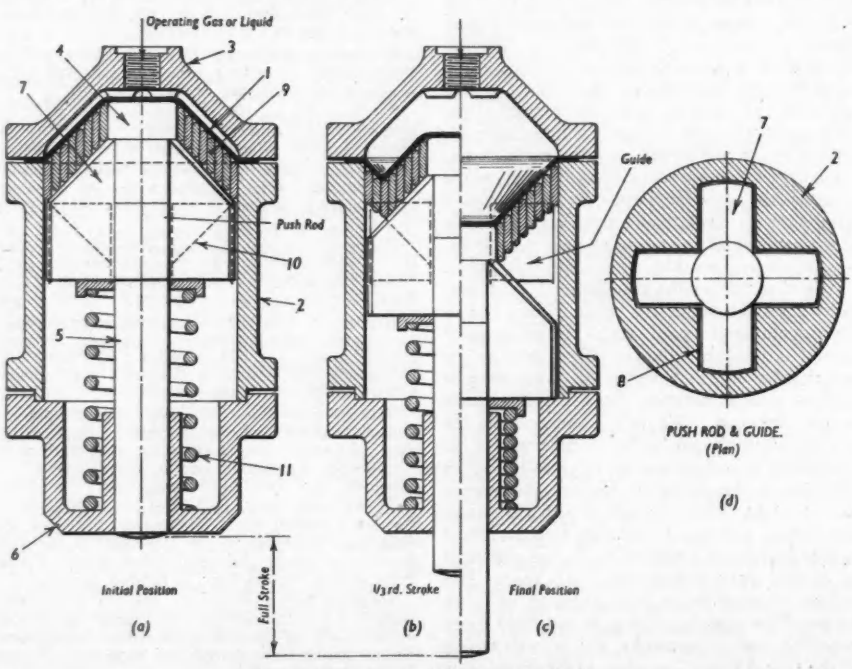


Fig. 1—Arrangement of diaphragm mechanism

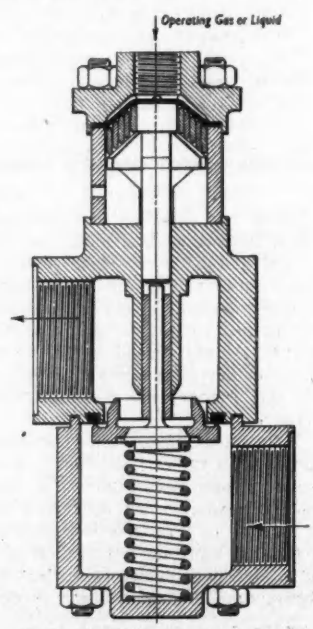


Fig. 3—Prototype diaphragm valve

increased by using thinner rings and by decreasing the clearances.

When the fluid pressure acting upon the diaphragm is released, the push rod is returned by the spring 11 to the initial position, the rings are successively picked up again by the support and the diaphragm returns to its original shape.

A number of tests have been carried out with a unit as shown in Fig. 3. The upper portion consists of the diaphragm mechanism already described and the lower portion is a two-stage shut-off valve. The diaphragm has a free diameter of 1·10in and a full stroke of 0·50in; clearance between all relatively moving faces of the diaphragm mechanism is approximately 0·01in; the number of supporting rings has been varied from four to eight and no lubricant was used. A solenoid-operated control valve, which alternately gave compressed air access to the diaphragm mechanism and vented it to atmosphere, was employed to operate the diaphragm at approximately 80 repetitions per minute.

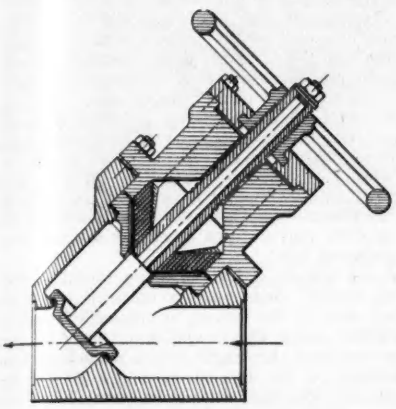


Fig. 4—Hand operated stop valve

The diaphragm consisted of soft quality P.V.C. and was conically premoulded; its thickness was 0·080in and it rested on five supporting rings having a diametral clearance of 0·020in. The operating air pressure was approximately 100 lb per square inch, and the water pressure in the valve chamber was also 100 lb per square inch. After some 70,000 repetitions the diaphragm and the whole mechanism were in perfect condition and would have been capable of operation at this pressure for a much larger number of reversals.

Another test was made with a flat (unmoulded) circular diaphragm of Latex rubber supported by eight rings with a diametral clearance of 0·002in. The thickness of the diaphragm was 0·013in, when unstressed, but it will be realised that, by pressing the flat disc into the conical shape during assembly the thickness will suffer a reduction. The operating air pressure was 400 lb per square inch and water pressure in the valve chamber 400 lb per square inch. After 1600 repetitions the diaphragm and the mechanism were in a perfect condition.

Some further applications are shown in Figs. 4 and 5. The former shows a hand-operated valve in which the diaphragm mechanism is used to replace the stuffing-box and to produce a leak-proof seal. The latter shows a hand-operated, straight-through tube valve. Here two diaphragms integral with a tubular connection piece are used as the diaphragm unit, and one of the faces of the diaphragm represents the sealing face of the valve.

Both valves provide a complete and very safe seal and may be used for chemically aggressive liquids or gases. It is important to notice that the direction of flow must follow the arrows in order to keep the diaphragm always in close contact with the ring sets

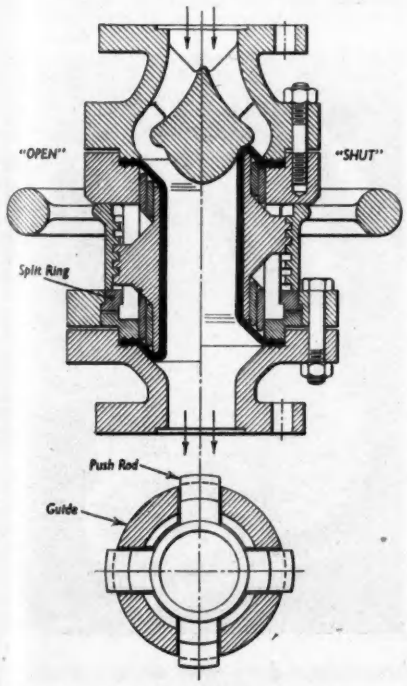


Fig. 5—Straight-through tube valve

To sum up, it may be said that the new high-pressure, high-stroke diaphragm mechanism is of simple design and no precision machining is required for its manufacture; successful preliminary tests have confirmed the usefulness of the device, and the results are, indeed, far ahead of anything ever achieved with flexible diaphragms.

The author acknowledges the permission of the Chief Scientist, Ministry of Supply, to publish this article. Crown copyright reserved. Reproduced by permission of the Controller, H.M. Stationery Office.

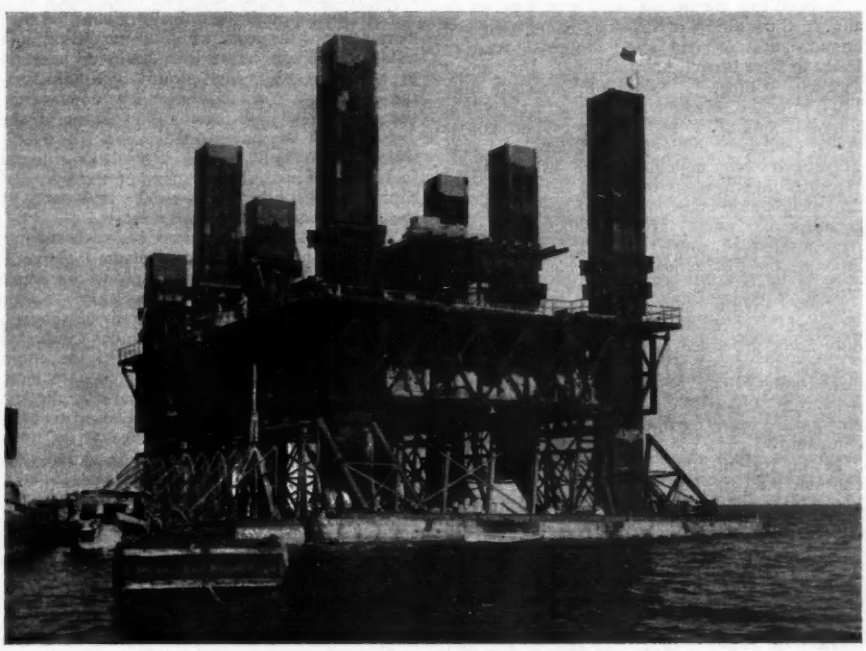
REFERENCE

W. Müller: "Improvements in or relating to High-Pressure Diaphragms." U.K. Patent Specification No. 690,945.

FOURTH WORLD PETROLEUM CONGRESS.—The fourth World Petroleum Congress is to be held in Rome from June 6 to 15, 1955, and will be under the patronage of the President of the Italian Republic. The General Organising Committee, under the chairmanship of Professor Marcello Boldrini, has prepared a full scientific and technical programme, and visits to the main Italian industrial, artistic and tourist centres will also take place. Plenary sessions and sectional meetings are to be held at the Rome Universal Exhibition Centre (EUR), a few miles from the centre of the city. Those interested are asked to apply to the National Committee, The Institute of Petroleum, 26, Portman Place, London, W.1, or directly to the General Secretariat of the Organising Committee of the Fourth World Petroleum Congress, Via Tevere 20, Roma.

Underwater Drilling Platform

RECENTLY, a movable island constructed of steel was set up in the oil concession which the Shell Petroleum Company, Ltd., acquired from the Ruler of Qatar, in 1952, and which extends over a large area of the Persian Gulf between the territorial waters of this sheikhdom. The point selected is 5 miles from the shore and has been chosen as a result of geophysical surveys carried out during the last eighteen months. A major problem in underwater drilling is to provide a stable platform to carry the weight of the rather bulky machinery required and at the same time withstand the forces exerted by high winds and heavy seas. At several wells, drilled at sea, the problem has been solved by building a steel island supported on piles driven into the sea bed. This method, however, has the disadvantage that should oil not be found then much of the steelwork cannot be salvaged economically and becomes a total loss. In certain areas, where the weather conditions are not severe, it is possible to construct small platforms and carry most of the machinery on a barge, but in the Persian Gulf, where storms are common, this is not practicable, and, based on experience in underwater drilling in the Lake of Maracaibo and in the South China Sea off the coast of Borneo, the Shell Company has developed a movable drilling island for work at Qatar.



Underwater drilling platform during construction at Doha

Our photograph shows the structure, which was fabricated in the Netherlands, shipped out to Doha in Qatar and erected there by George Wimpey and Co., Ltd. The main deck of the drilling platform measures 140ft in length by 40ft in width, and is set at about 40ft above the level of the water and carries a drilling rig which is capable of reaching a depth of 7000ft to 8000ft. Owing to the high winds and short seas encountered in the Persian Gulf it is impossible to relieve the drilling personnel at regular intervals and to provide for this contingency accommodation, including refrigeration, storage, working facilities and air conditioning for two complete crews, has been fitted on the platform. The platform, which, together with equipment, weighs 1200 tons, was erected on two 1000-ton pontoon barges and towed out to the selected drilling location about 35 miles north of Doha and then eight heavy steel spuds, incorporated in the structure, were lowered to the sea bed. After this a series of high-power hydraulic jacks lifted the platform itself up on the spuds, thus allowing the pontoons to be withdrawn. When the drilling of the well is completed the operations will be reversed and the platform towed to a new drilling site.

"Comet" Court of Inquiry

THE Court of Inquiry into the "Comet" disaster at Elba was opened at Church House, Westminster, on Tuesday, October 19th. This court will also consider the accident to the "Comet" which crashed three months later at Naples.

Circumstances of a similar nature have attended the loss of three "Comet" aircraft, all of which had apparently disintegrated shortly after or before reaching cruising altitude. There were no survivors and a total of ninety-nine passengers and crew perished. The first "Comet" "G-ALYV," crashed near Dum Dum, Calcutta, on May 2, 1953. A formal inquiry was held in India. Wreckage from the machine was assembled on a skeleton frame at the Royal Aircraft Establishment, Farnborough, and an exhaustive technical investigation was undertaken. The sequence of failure was established, but no structural weakness was found. It was concluded that the aircraft had been led into an abnormal condition of flight by some unknown circumstance or had met abnormal weather likely to have broken any machine. The second aircraft "Comet," "G-ALYP," crashed near Elba into the Mediterranean Sea and within thirty-six hours Sir Miles Thomas had voluntarily grounded its "Comet" fleet. Salvage operations were concluded and after a very rigorous investigation of every aircraft in the fleet no definite cause of the disaster could be established. Some fifty modifications were incorporated in every aircraft, however, and amongst the few major ones it was noted that armour plate was fitted round the turbine regions. With these modifications fitted, "Comet" services were resumed on March 23rd, only to be grounded again on April 8th, when "Comet" "G-ALYY" fell into deep water near Naples. The "Comet" aircraft, together with its "Ghost" centrifugal flow turbo-jet engines are made by the de Havilland group of companies.

In the present court of inquiry, which is to consider only the last two disasters, Sir Lionel Heald, Q.C., M.P., appears for the Crown, with Mr. J. P. Graham, Q.C., and Mr. P. J. Stuart Bevan. Sir Hartley Shawcross appears for the de Havilland Company.

Sir Lionel began by outlining the few known facts of the Elba crash. He noted that it was the first machine to enter the "Comet" scheduled services on May 2, 1952, and one of the first made by the company. It had logged a total of 3681 hours. On the fatal stage of its last flight it had taken off from Ciampino airfield, Rome, at 09.31 hours G.M.T., Jan. 10, 1954 and its last formaltransmission was made at 09.50 hours. It was then at a height of 26,000ft climbing to 36,000ft. The aircraft had, however, been in regular radio contact with another B.O.A.C. aircraft and a transmission to this aircraft from the "Comet" abruptly ceased at 09.51 hours. This was now believed to be the moment of disaster. Two witnesses in an affidavit heard roaring sounds and saw blazing wreckage plummeting into the sea, the time according to one being 11.03 hours.

The "Comet" which crashed three months later near Naples, April 8th, after taking off from Rome also, had flown 2704 hours. It took off at 18.32 hours and reported during its climb to 35,000ft at 19.05 hours. It was not heard again.

Sir Lionel referred to the salvage operations at Elba and to the recovery of all four engines, which, he said, played no part in the disaster.* He then commented on the report submitted by Sir Arnold Hall, director of the Royal Aircraft Establishment, where all the accident investigations had been undertaken. It was, he said, one of the most remarkable pieces of scientific detection work ever done and he believed that the main conclusion in Sir Arnold's report would command acceptance: the fuselage structure had suffered a fatigue failure and explosive decompression had occurred.

Sir Arnold Hall gave evidence at the inquiry on Thursday, October 21st. During the investigations he said that 100 hours' flying had been accomplished in a heavily instrumented "Comet" aircraft. Although he remarked that they had no definite knowledge that the cause of the failure lay in the pressurised fuselage, the aircraft was not flown pressurised and flights were restricted to fifteen minutes' duration. A "Canberra" aircraft trailed this machine at all times.

Cause of the Disaster

Sir Arnold told the inquiry that the aircraft probably broke into six main pieces; that the first disruption took place in the region of the top centre of the fuselage in the region of the dielectric ariel panel, and that there was a very violent disruption of the pressure cabin. He then demonstrated the sequence of disintegration on a model. The top centre first disrupted laterally in a violent way, and almost simultaneously the rear and front fuselage fell downwards, then the wing tips, leaving the centre of the aircraft with the power plants as a free agent, which then caught fire as a result of integral fuel tank failure. The manner of the first disruption was confirmed by marks that parts of the cabin made when blown sideways.

Sir Arnold had also described experiments using a one-tenth scale model of the "Comet" in "Perspex," in which they sought to reproduce the effects of explosive decompression. It was fitted with scaled seats and dummy passengers, and placed in an evacuated chamber exhausted to simulate an altitude of 40,000ft, the cabin differential pressure being 8½ lb per square inch. This cabin was then caused to burst at the top where the Elba "Comet" was believed to have burst with substantially the same kind of hole. Its disruption was photographed. After one-thirtieth of a second (actual time scale), some of the seats had begun to move forward, and after one-tenth of a second complete chaos developed with seats and passengers flying in all directions, striking the roof or going straight through the hole.

Sir Arnold continued his evidence the next day (Friday), and stated his belief that fatigue probably caused the primary failure of the pressure hull structure in the Elba "Comet." In the light of subsequent tests with a similar "Comet" which was fatigue tested to destruction, it had been revealed that both the Elba and the Naples aircraft had exceeded their safe fatigue life. He said that he knew of no physical test to indicate how much a material was fatigued. Furthermore, with the metals in question, the fatigue phenomena were rather variable and that, based on the average life of a structure, the average life of a specimen could vary by a factor of six, according to whether the specimen was a weak one or a strong one. He did not suggest that there was any defect in the alloys used, as test specimens from the wrecked aircraft had been up to or better than specification.

Near the direction-finding windows (point of primary failure) he said cracks had been found which he believed to have been formed during manufacture because of drill holes at the ends.

Sir Lionel said he did not suggest that anyone should form an opinion about this before hearing the evidence of the de Havilland company, but he ought to ask the witness for his opinion of the importance of the cracks.

Sir Arnold Hall replied that their presence rather suggested that the manufacturing process was capable of cracking the material, and although one might see a crack formed by such a process—and these were plainly seen in the factory and drilled—one was always worried about cracks that might not be seen. Hair cracks were worrying because they often acted as a fatigue origin. The inference he put on the cracks was that he could not totally eliminate them. They might have accelerated the onset of fatigue, but he did not think they had caused the accident in any direct sense at all. He could not eliminate the possibility that fatigue was brought on a little earlier than it might otherwise have been because one did not know whether there was an incipient crack. The fatigue life of the cabin in any case was low. Sir Arnold said, in reply to Sir Hartley Shawcross, that when the failure of the aircraft took place he believed it started at a fatigue crack which developed not during manufacture, but during the life of the aircraft, and when the burst took place it happened that the failure ran through a manufacturing crack. It started as a fatigue origin.

He thought it was wise not to use a manufacturing process which caused cracks if the structure was a primary structure taking a primary load, not because cracks had had anything to do with it, but because there might be cracks not seen which might form a fatigue origin. He thought there could be a process which would avoid incipient cracks.

Dr. P. B. Walker, head of the aircraft structures department at Farnborough, said that his view on the cracks in relation to the accident was that they did not accelerate fatigue failure or shorten life.

The inquiry was resumed on Monday, when Sir Hartley Shawcross complained about the reporting of the inquiry in connection with the cracks, saying that some impression had been created that the cracks had a really significant bearing on the accident when Sir Arnold had indicated that that was not his view. Sir Arnold replied that he had not quite said the cracks were not, in fact, significant, but he agreed that crack or no crack, the aircraft would have failed in fatigue at about that time. On this day, also, it was stated that a letter had been received from Mr. B. Jablonsky, who disagreed with the findings in respect of the primary failure. He said that Sir Arnold's evidence was wrong. The court was deciding whether it should ask Mr. Jablonsky to submit a statement. Mr. Jablonsky is managing director of Jablo Propellers, Ltd. He is reported to have said that the causes submitted so far were only secondary and that there had been no substantial statement on the basic problem.

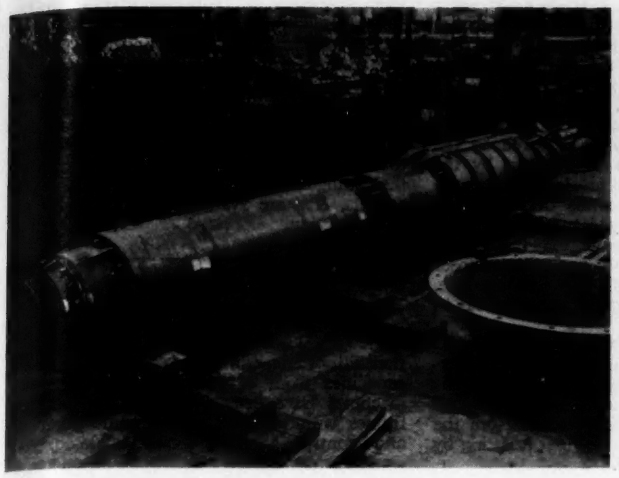
The court was adjourned until yesterday.

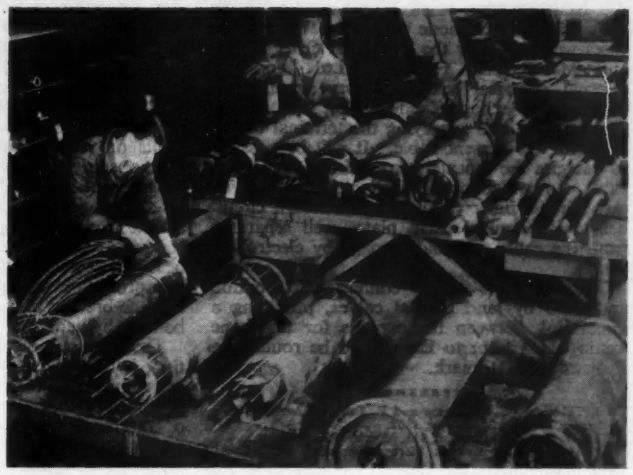
* Reports of these operations—the fatigue tests, the earlier modifications, and other aspects of the investigation—have appeared in THE ENGINEER, January 22nd, page 145; January 29th, page 180; March 12th, page 373. It will be recalled that at the time of the salvage operations, the rotor of one "Ghost" engine was missing. During our last visit to the wreckage it was noticeable also that the stator ring of this engine was very badly burnt.

High-Tension Submersible Pump Set

A WET-TYPE high-tension submersible motor has been developed by the Harland Engineering Company, Ltd., of Alloa, Scotland. After initial works tests, the motor and pump unit have been installed in the Castle Pit of the National Coal Board's South-Western Division to undergo a period of experimental running under normal field conditions. The motor is

End winding of partly wound four-pole submersible motor





A submersible pump set designed to deliver 1000 gallons per minute against 570ft head is shown on the left. The motor operates on 400/440V and is rated at 205 h.p., 1465 r.p.m. Batch production of submersible pump motors is shown in the right hand view

supplied from 3300V, three-phase, 50-c/s mains, and develops 250 h.p. at 1450 r.p.m. It drives a twelve-stage pump which delivers 600–650 gallons per minute against an 800ft to 830ft head.

In the early stages of development, submersible borehole pump sets of 120 h.p., running at 2900 r.p.m., were successfully used. Later, a 450 h.p., 1450 r.p.m. set was built which delivered 1000 gallons per minute against a 785ft head. The motors of these sets operated at the comparatively low tension of 440V and 550V, and this meant that heavy leads had to be used which were both costly and difficult to get into and out of boreholes. The difficulty of installation is a great drawback, as the sets have to be lifted periodically for servicing.

As regards the insulation of the windings, one of the earliest materials which was tried was polyvinyl chloride, and this is still considered to be the most satisfactory substance. Its electrical resistance is not affected by immersion over long periods, and it is very resistant to abrasion. Owing to the great flexibility of P.V.C. covered wire, the ends of the windings must be efficiently braced to withstand the hydrodynamic as well as the electrical forces, but great care must be taken to avoid local stress concentrations when winding the coils with tape, for P.V.C. will flow plastically under prolonged stress. Polyvinyl chloride tapes, because of their own plasticity, have been found to be a most suitable material in this work.

In order to reduce the number of joints to a minimum, a pull-through winding is used with a single length of wire for each phase. In a star-connected machine there are therefore only four joints, viz., the star point and the three connections to the trailing cable. Special waterproof adhesive tape is used to insulate the joints, which must be quite free from dust and grease before the tape is applied. The wound stator is immersed in water and the insulation resistance checked every day for a week, after which a flash test is applied to the winding.

The diameters of both the motor and the pump are limited by the size of the borehole in which they have to operate; a 60 h.p. motor may have to go down a borehole of only 10in diameter. The ratio of stator core length to diameter is therefore large and of the order of 4:1 (by comparison, for a fan-cooled motor this ratio would at most be about 0·7 to 1).

The bearings are water lubricated, and consist of plain carbon bushes for the journal bearings and tilting carbon pads for the thrust bearing. Journals and thrust collar are of stainless steel. When the set is shut down, since normally a non-return valve is not fitted to the pump, the water in the rising main of a deep installation will flow back and drive the pump in reverse as a turbine, in some cases for several minutes. The thrust bearing must therefore be able to operate in both directions.

The well or mine water is often rather corrosive, but it has been found possible to reduce corrosion to a minimum by filling the motor with distilled water and sealing it with a carbon seal of conventional design, an expansion chamber being provided for the distilled water. With these precautions, running times of 30,000 to 35,000 hours without servicing are stated to have been obtained in some instances.

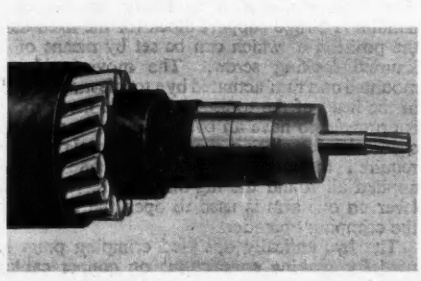
The recently developed 3300V motor is similar to the standard four-pole motors, except for the difference in size of the windings and cables. The number of joints actually in contact with water was reduced to one—the star point—the other ends of the windings being taken straight to a sealing box on the motor frame. The joints were insulated by covering them with plasticised polythene, and then wrapping them with adhesive waterproof tape. The chamber was then filled with waterproof sealing compound. No difficulty was anticipated with the star point, which, of course, is at a very low potential to earth. After an immersion test lasting for a week, the motor was run for some time, and after a few minor modifications it was again subjected to an immersion test, this time lasting six months, during which period the normal operating voltage was applied daily by a flashing transformer. The set was then installed at Castle Pit, where it has been running since the middle of July.

Anglo-Norwegian Telephone Cable

THE laying of a new submarine telephone cable between Aberdeen and Bergen was completed by H.M.T.S. "Monarch" on Saturday, October 9th. It is a coaxial cable and, with seven submerged repeaters installed, it will enable thirty-six simultaneous two-way telephone circuits to be maintained over more than 300 nautical miles.

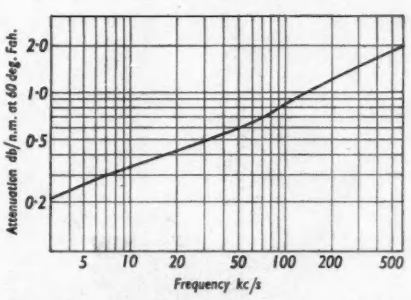
The telescoped view reproduced herewith shows that the cable is of similar construction to the Netherlands-Denmark cables[1] laid in 1950.

Like these cables, it was manufactured at Telcon Works, Greenwich, by Submarine Cables, Ltd., and it is insulated with "Telcothene," a mixture of polythene[2] and polyisobutylene supplied by Imperial Chemical Industries, Ltd.



Telescoped specimen of coaxial telephone cable laid between Aberdeen and Bergen by H.M.T.S. "Monarch"

The inner copper conductor is of composite make-up, comprising a strand of seven wires each 0·0765in diameter, around which a tape, 0·775in by 0·015in, is longitudinally folded, the interstices being filled with a suitable compound. This construction combines mechanical flexibility and the low d.c. resistance desirable for power-feed to the repeaters, with the transmission efficiency necessary at high carrier frequencies. Grade 2 polythene[2], mixed with 5 per cent polyisobutylene and a small amount of antioxidant to guard against slight deterioration of properties during processing, was extruded on to the conductor in a single operation to a diameter of 0·935in. The outer copper conductor consists of a layer of six tapes 0·475in by 0·015in applied with a long lay and bound by an overlapping short-lay tape 0·004in thick. Corrosion protection is afforded by a "Telconax" tape, impregnated with a rubber-bitumen-wax compound. A serving of two layers of tarred jute yarn was followed by alternative kinds of armour, fifteen No. 2 or twenty-one No. 6 S.W.G. galvanised steel wires, according to the depth of laying, and the cable was



Attenuation characteristic of Anglo-Norwegian telephone cable at 60 deg. Fah.

completed by two layers of tarred jute yarn applied with bituminous compound. To minimise extraneous electrical interference, the outer conductor was insulated with Telcothene and covered with lead, for a length of 0·5 nautical mile at each end of the cable; in this case the armour was twenty No. 2 S.W.G. wires.

In the accompanying diagram the realised attenuation at 60 deg. Fah. is given. Frequency bands 24 to 168 kc/s in the direction of Aberdeen to Bergen, and 208 to 352 kc/s in the opposite direction, will be used. This allocation is made possible by the inclusion of seven submerged repeaters at approximately 38·8 nautical mile spacing, the largest number to be included so far in a single submarine cable. The design of the repeaters was a modification of that previously standardised by the Post Office[4] for shallow water. The repeaters are of "torpedo" shape, with cable entry at each end, similar in pattern to those it is intended to use on

the Newfoundland-Nova Scotia section of the Transatlantic Telephone project[5]. The repeater cases were made by the Telegraph Construction and Maintenance Company, Ltd., and the internal electrical equipment was supplied by Standard Telephones and Cables, Ltd.; the latter firm is also supplying the terminal equipment for the present cable. It will be possible to energise the repeaters from either end of the cable, for which purpose direct current is fed through the inner conductor, the return circuit being via terminal earth plates well separated from the cable to avoid damage by electrolytic action.

The new cable will be connected to London and Oslo by land coaxial cables, providing a direct link between the capitals for telephone traffic which hitherto has had to be routed via Holland and Denmark.

REFERENCES

[1] J. Tj. Visser, K. L. Larsen and F. Fairley, *Electrical Communication*, 29, 186, September, 1952.
[2] M. W. Perrin, *Research*, 6, 111, March, 1953.
[3] Government Department Electrical Specification No. 27, 1950.
[4] R. J. Halsey and F. C. Wright, *Proc. I.E.E.*, Part I, 101, 167, July, 1954.
[5] *British Engineering Overseas*, 36, 424, June, 1954, and *Telcon House Magazine*, No. 23, page 1, April, 1954.

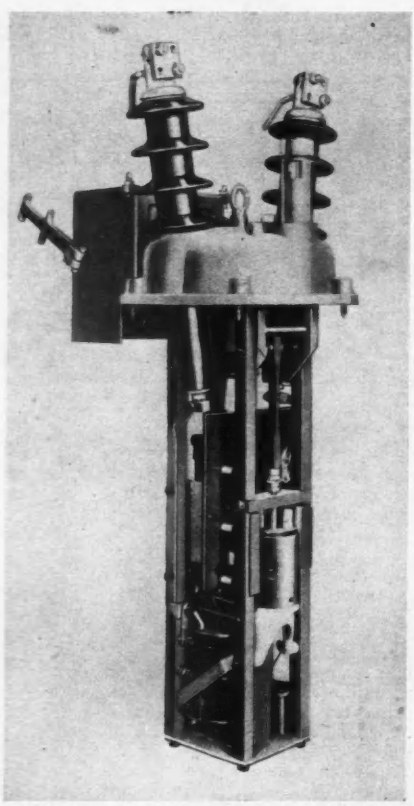
11kV Automatic Circuit Recloser

IN co-operation with the Midland Electricity Board, British Thomson-Houston Company, Ltd., Rugby, has developed an 11kV automatic circuit recloser for rural supply lines. Made for single-phase or three-phase service, the recloser can be supplied in ratings from 5A to 100A and with a breaking capacity of up to 50MVA.

The recloser is a single-pole dead-tank oil circuit breaker, which is normally held closed by springs. When a fault occurs, a series-connected solenoid opens the breaker, after which the solenoid plunger returns to its initial position. Solenoid coils are supplied in a series of ratings, the breaker being set to operate at twice the rated current.

The standard unit is arranged to give four consecutive opening operations on a persistent fault, and then to lock open. For faults cleared prior to the last opening the mechanism will reset, with a time delay, to restore the full four-shot operating cycle. The first opening occurs instantaneously on the fault developing, so that the fuse in the affected circuit does not have time to blow. After a delay of about one second the circuit is restored, and should the fault persist the current is interrupted again immediately. Experience has shown that 80 per cent of the faults on rural power lines are cleared by the first opening, and another 5 per cent by the second opening. The circuit is subsequently closed twice more, at intervals of about one second, the trip being delayed to allow the fuse concerned to blow. Should the fault have occurred between the fuse and the recloser this procedure will obviously not clear the line, and the breaker remains locked open and has to be reset by hand.

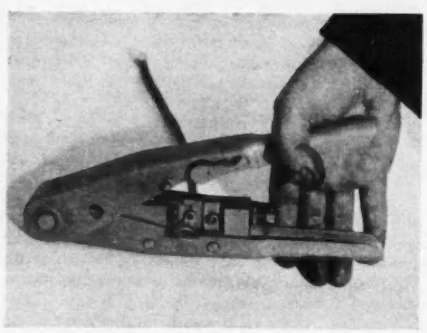
The recloser, of which we show an illustration, is arranged for pole mounting, with alternative positions for the mounting bracket. It is equipped with an "on-off" indicator and operation counter, both easily visible from the ground, and is arranged for manual resetting by means of an operating pole.



11kV circuit recloser with oil tank removed showing the mechanism

Solderless Electrical Wiring Connections

IN our issue of January 27, 1950, there was described the "Breeze" tool made by the Plessey Company, Ltd., Ilford, Essex, for making solderless joints in electric cables. With this method joints are made by means of connecting lugs fixed on the cables by a special hand-operated crimping tool. In this original tool, which is still made by the firm for light work, indentations are formed by dies being forced into each side of the lug thimble to distort it and firmly grip the cable in its bore.



Heavy-duty pliers used for fixing connections on electric cables

As a further development of this method the company recently introduced two new tools—a heavy duty crimping hand plier and a hydraulically operated tool. These new tools, instead of making two indentations in the lug thimble, close it tightly on the full circumference of the cable with two dies The dies each have three faces and interlock when they are closed together and form a hexagon on the outer circumference of the lug.

The new heavy-duty, hand-operated plier is stated to be suitable for crimping copper cable and lugs up to 50A carrying capacity and aluminium conductors for up to 35A. One of the pliers can be seen in use in the photograph we reproduce. In one of its heavy pressed steel handles is a rigid support block for the fixed die, the position of which can be set by means of a knurled locking screw. The moving die is mounted on a ram actuated by a toggle mechanism in the head of the tool. This toggle mechanism is arranged to have an over-centre movement to ensure that, on closing, the full peripheral pressure required to make a successful connection is applied all round the lug on the cable. A cam lever on one arm is used to open the tool after the crimping operation.

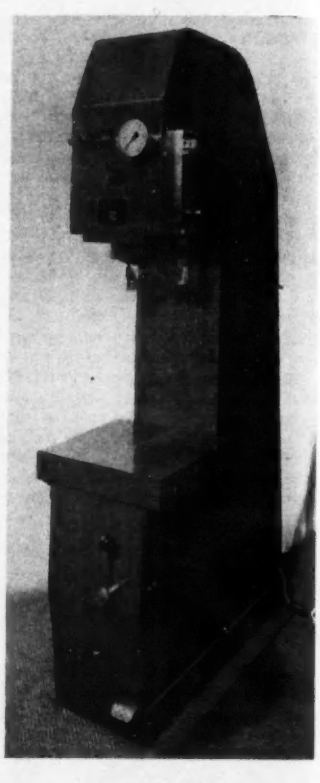
The hydraulically operated crimping press is used for making connections on copper cables carrying up to 280A and aluminium cables carrying up to 200A. It consists of a foot-operated hydraulic pump connected through flexible piping to a crimping head. This head carries a fixed die and its moving die slides in guides and is mounted on the ram of a hydraulic cylinder. These dies, like those of the hand tool, compress the lugs on the full circumference of the cable and impart a hexagonal shape on the outside of the lug thimbles.

A range of dies is made for both of the new tools to suit them for all sizes of cable within their range and a variety of tags, plug pins, sockets, &c., are available for use in this form of connection.

Hydraulic Presses

A NEW range of hydraulic presses now being made by Joseph Potts, Ltd., North Road, Bellshill, Lanarkshire, is available in seven capacities from 7½ tons to 150 tons. These machines have heavy welded mild steel plate frames within which the hydraulic pump unit and control gear is totally enclosed. The smallest machine has a stroke of 7in and all the others a stroke of 14in and both hand and foot-operated control are fitted.

A "Vickers Detroit" motorised pump and control gear is used to power the 7½-ton capacity machine, whilst a "Beacham Swashplate" pump and control gear is fitted to the heavier machines. A variable pressure relief valve enables the machine to be set for operating at a predetermined pressure and the ram stroke can be adjusted.



Small hydraulic press with variable ram stroke and ram pressure adjustment

The general arrangement of one of the new presses can be seen in the accompanying illustration. One of the standard 20-ton presses has a 20in square table with a maximum daylight distance of 20in between the ram and the table. With this machine the approach speed is about 140in per minute and the pressing speed 45in per minute.

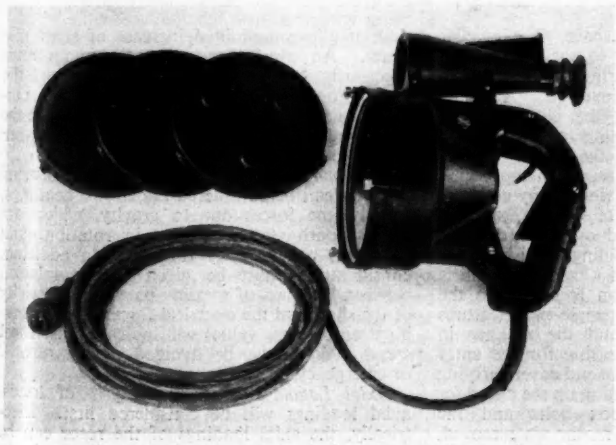
ANTWERP REFINERY.—At the Antwerp refinery of Albatros S.A. Belge pour le Raffinage de Petrole, a new Houdriflow catalytic cracking unit has recently gone on stream. This unit, which has a capacity of 3600 barrels per day, will produce high octane petrol and has been constructed by Head Wrightson Processes, Ltd., in conjunction with the Houdry Process Corporation of New York.

Improved Signalling Lamp

A NEW lamp, the "Longrange" signalling lamp, which is a product of Aldis Brothers, Ltd., Birmingham, and marketed by Kelvin and Hughes (Marine), Ltd., was demonstrated recently on board the "Wellington," the headquarters ship of the Honourable Company of Master Mariners. Naval signallers sent messages from the "Wellington" to Shell Mex House and from there the signals were relayed to the Monument and then back to the "Wellington." It is claimed that the new lamp, which complies with the specifications laid down by the Ministry of Transport, satisfies all the essential requirements of an efficient signalling lamp and that it produces a signal five times more powerful than the previous model.

In this new unit, which we illustrate, the bulb burns continuously at full brilliance and signals are produced by the movement of a tubular shutter which cuts off the light of the lamp and prevents it reaching the reflecting mirror. When the shutter is withdrawn from the hole in the centre of the mirror the entire mirror gives a full flash; clear signals can be transmitted at three dots per second or about twelve words per minute. The lantern case, an aluminium pressure die casting, includes a handle and contains the light source, reflector and cylindrical shutter. The bulb used is a "prefocus" 60W, 12V, with a single axial coil and the reflector is of polished and anodised aluminium of 99·9 per cent purity, while the shutter is a thin-walled cylinder of aluminium alloy anodised black. Fitted on top of the body is a built-in telescopic sight having a 2× magnification and being fully watertight. It is of simplified optical design which gives increase in light transmission. The divergence of the signal beam to about 6 deg. simplifies the task of holding a fast-moving target even in rough seas. In order to reduce the dazzle effect at close quarters and to provide a higher degree of secrecy for night signals the lamp is equipped with the Aldis "Secret Device," which consists of neutral filters and a metal plate with light restriction apertures, the candle power being reduced to between eight and fifteen. Red and green filters fit over the frontal glass to change the colour of the beam.

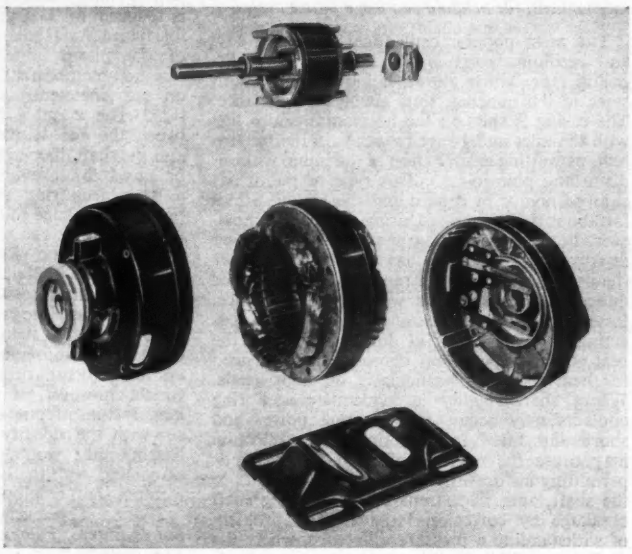
The body of the lamp is earthed to eliminate risk of electric shock and the lamp can be operated on normal ships' mains voltages either a.c. or d.c., by using a suitable resistance or transformer. To satisfy Ministry of Transport requirements a secondary battery for powering the lamp must be carried on board ship and accordingly the equipment includes an Aldis battery which has a working life 50 per cent in excess of requirements. The lead-acid battery is of non-spill design carried in a wooden box protected by acid-resisting paint and is rated at 12V, 15Ah at 20-hour discharge rate. The new lamp is strongly made, watertight and proof against corrosion by sea-water and, when packed in a carrying case complete with filters, cable and spares, weighs 14·5 lb (6·6kg), while the battery in its case, uncharged, weighs 22·25 lb (10·1kg). The lamp itself weighs 4·75 lb and is of balanced design so that it can be operated for long periods without fatigue.



Long-range signalling lamp "Mk. X," complete with sighting telescope

Interchangeable Fractional H.P. Motors

A RANGE of fractional horsepower a.c. motors similar in appearance to the present designs but more compact and of less weight, has been produced by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. Apart from the flange-mounted motors, they are interchangeable with other motors made to B.S. 2048 : 1953, and with American motors made to the N.E.M.A. standard. The accompanying illustration shows details of the design. The stator laminations are riveted unde pressure to ensure rigidity, the ends of the pack being spigotted true with the bore for mounting the bearing brackets. A one-piece pressing screwed to the stator, ensures correct centre height and accuracy of alignment of the foot-mounted motors. Where silent operation is required, the motor is supported from the nose of the bearing brackets in oil-resistant resilient end rings.



Components of fractional horsepower motor, including rotor, centrifugal switch, stator, bearing brackets and pedestal pressing

The bearing brackets are of pressure cast aluminium and are fitted with steel-back white metal bushes finished by diamond boring. Lubrication is by means of felt wick feeds which are spring-loaded in contact with the shaft, and can be replenished with oil when necessary. Substantial thrust washers have been provided to absorb the end thrust. In place of the plain bearings, ball bearings in grease-packed housings are available if desired.

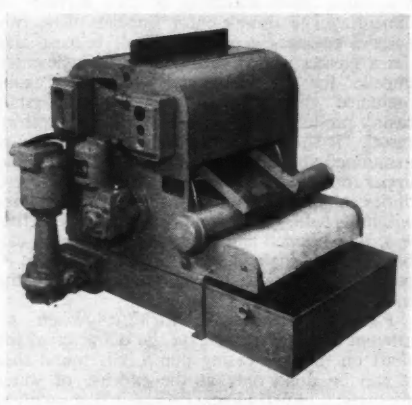
The squirrel-cage rotor is cast in aluminium with integral ventilating fans and has a rotor shaft of high-grade steel, accurately ground to size with special attention to bearing finish. The complete rotor is dynamically balanced.

The single contact centrifugal starting switch is equipped with silver contacts for long life and mounted on a moulded Bakelite base fitted inside the bearing bracket. Its mechanism is pressed on to the shaft and is silent in operation. The terminals are incorporated in the switch base, which is marked to correspond with the diagram of connections. A cable entry hole in the side bracket is screwed ¾in electrical thread and fitted with a removable plug, and slots are provided in the casting for T.R.S. cable entry. A removable cover allows easy access to the terminals. For capacitor starting an electrolytic capacitor sealed in a sheet metal case is mounted direct on the stator.

The double layer slot insulation is reinforced at the ends overhanging the core and wedges of leatheroid are fitted in the slots to hold the windings securely.

Magnetic Coolant Separators

A RANGE of automatic magnetic coolant separators is being manufactured in this country under licence by Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11. We show an illustration of one of the "Barnesdril" separators, which extract from the coolant ferrous particles and entrained abrasive by means of a slowly rotating drum which is magnetised by internally arranged "Alcomax" permanent magnets. The coolant flows around the bottom half of the cylinder, the optimum width of the gap depending on the viscosity. The machine has been designed to cope with viscosities of the order of 150 seconds Redwood at 100 deg. Fah. (somewhat thinner than S.A.E. 10), but more viscous liquids can be treated by narrowing the channel by means of inserts.



Magnetic separator showing coolant pump, geared motor for rotating drum and discharge chute for swarf and abrasive

LIST OF GOVERNMENT PUBLICATIONS ON BUILDING.—We have received from the Ministry of Works a booklet listing publications on building and allied subjects, which have been issued by Government Departments and are now available. The booklet should prove a useful reference catalogue for builders, civil engineering contractors, professional men connected with the industry, foremen, students and operatives. It lists under appropriate headings not only books, but series (such as National Building Studies and Post-war Building Studies), pamphlets, advisory leaflets and digests, issued by the Ministries of Works, Housing and Local Government, Labour and National Service, and Education, and the Building Research Station, and the Laboratories of Road Research and Forest Products Research of the Department of Scientific and Industrial Research. The booklet, "Sectional List No. 61," can be obtained from H.M. Stationery Office, free of charge.

Modern Developments in the Use of Large Single-Entry Centrifugal Pumps

By H. H. ANDERSON, B.Sc. M.I.Mech.E., A.M.I.C.E.*

A paper under this title was read and discussed at the Institution of Mechanical Engineers last Friday, October 22nd. Extracts are here reprinted. In parallel with the electric motor and the steam turbine, which provide suitable high-speed power, the centrifugal pump has been developed to a high degree of reliability and efficiency. This paper describes a recent step in this development, namely, the research manufacture and adoption of single-entry pumps, combined with their driving mechanisms, for medium and large power duties.

THE most popular centrifugal pump for low and medium heads is the double-entry split-casing type which allows liquid to enter both sides of the impeller, thus giving axial balance. The casing is split on the horizontal centre line with the inlet and outlet branches in the bottom half, permitting examination of the pump without disturbing pipe joints. This type of pump has enjoyed favour in Britain and the United States for about thirty years. During this period, however, heads, powers and speeds have increased rapidly and the need has arisen for greater rigidity to meet the upper range of these increased duties without excessive wear or maintenance. Research into the existence of radial forces acting on the impeller at duties other than the best efficiency point has demonstrated the need for heavier shafts, particularly on high heads. Where shaft rigidity is inadequate neck ring contacts may occur, thus wasting power and shortening life. In addition, shaft deflection may cause the opening of shaft sleeve joints, permitting air drawing and/or access of liquid to the shaft, and, in extreme cases, causing shaft breakage by corrosion fatigue. The problem of withstanding a pressure difference, where the shaft enters the casing, is rendered more difficult if shaft deflection occurs.

The double-entry feature involves a split and several bends in the flow of liquid from the inlet branch to the impeller. This causes friction loss and poor distribution of flow in the impeller inlet, which prejudice performance. The split of the casing is a further cause of hydraulic loss since exact matching of cast surfaces is difficult. The double-entry impeller with two narrow passages is more difficult to cast and has a greater wetted surface than a single-entry impeller for the same duty, which facts again prejudice efficiency. The horizontally split casing presents a difficult shape for a pressure vessel. It should be emphasised that the faults mentioned above are mainly associated with the upper ranges of head and with fairly severe duties, and that the split-casing type of pump, within its field, gives excellent service. Nevertheless, if a heavier and more efficient design can be developed there is every incentive to adopt it, particularly on the higher heads and for the more difficult duties.

Pumps Designed for Rigidity.—When an attempt is made to increase the diameter of the shaft on the split-casing pump it is found that it can be done only at the expense of water passages, thus prejudicing hydraulic performance. By making the impeller of the single-entry type, however, the flow of water can enter at one side and the shaft can enter the impeller at the other side with no restriction to diameter. At the same time, the water flow to and through the impeller is simplified, thus giving an improvement in performance. The large increase of shaft diameter that can therefore take place without prejudice to water-flow passages permits a very generous margin of safety in respect of rigidity. The actual increase in rigidity is about tenfold and is proved by running the pump dry. A single-entry impeller can readily be made "blind" and the hub of the impeller can extend out to the atmosphere, thus preventing any air drawing. The question of the opening of the sleeve joint under radial loading does not therefore arise and [as shown in the paper] shaft deflection is reduced to a negligible figure. Axial balance of the pump impeller can be obtained readily on the single-entry design. The annulus between the eye diameter and the shaft diameter is balanced by providing a back neck ring and piping its leakage to the inlet branch. The area of the shaft and sleeve diameter is balanced when the inlet pressure equals atmospheric pressure, but with a suction lift or a positive pressure, an end thrust occurs which, however, is relatively small in comparison with the capacity of bearing that would be associated with the diameter of shaft employed.

Unit Construction, Single-Entry Pumps.—The change from split-casing, double-entry pump to end cover type of single-entry pump facilitates the construction of a combined pump and motor unit, since the motor shaft is ideally suited to an overhung impeller. This development is, however, so intimate a union of pump and motor that very close collaboration between electrical, hydraulic and mechanical designers is essential.

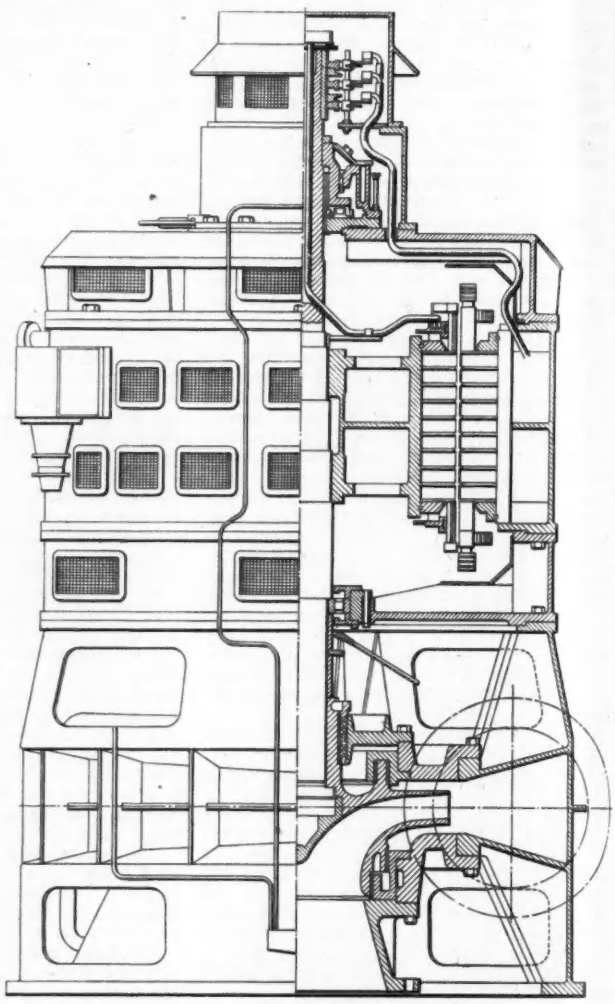
The firm with which the author is associated has developed single-entry combined pump and motor units for large powers. Since pumps and motors are made in the same factory it is an advantage to make a combined machine, avoiding shaft and bearings in the pump proper and saving power, cost and space. The impeller is, therefore, fitted directly to the motor shaft which, together with its bearings, is designed to carry the additional loads involved. A saving in efficiency accrues from the elimination of pump bearings and coupling and from the reduction of shaft whip at the gland.

In the vertical arrangement, the pump casing becomes the motor stool, giving a very compact unit occupying a minimum of space. Examination of the pump is carried out by lifting the motor and impeller, thus avoiding the disturbance of pipe joints. A section of a combined unit is shown in Fig. 1. Attention is drawn to the particularly heavy shaft, the single-entry features with the blind impeller, and the manner in which the opening in the casing for the entry of the impeller is closed by an end cover carrying the stuffing-box. When opening up the pump for examination the stuffing-box bolts and the holding down bolts for the motor are removed, thus permitting the motor and impeller to be lifted as a unit. This combined unit can also be arranged with a horizontal shaft, but the advantages of accessibility and space economy naturally decrease somewhat with horizontal application.

Several of these units are in operation in waterworks, chemical plant, oil refineries, &c.

THE MECHANICAL DESIGN OF COMBINED MOTOR PUMPS OR TURBO-GENERATORS

When a pump and a motor are so intimately united that they have a common shaft and bearings these parts must be designed adequately to carry the double duty without undue deflection or risk of failure. It is in this respect that the single-entry impeller is of considerable value, since it allows unlimited increase of shaft diameter. An overhung single-entry pump must necessarily have two bearings to support the shaft. For economy in space, power and expenditure of metal, the next logical step is to place the rotor and stator of the electrical unit between these two bearings.



Fabricated construction is employed throughout, all plate in contact with water being of clad stainless steel.

Fig. 1—Section of combined motor pump unit for vertical operation

Shaft and Bearing Loadings.—Shaft and bearing loadings can be considered under two headings, namely, the forces due to gravity, which are present both stationary and in rotation, and the loads produced by rotation. In addition, consideration must be given to the relation between the mass of rotating parts, the elasticity of the shaft and the electrical forces, as the combination of these values will indicate the critical speed which must be avoided during normal or emergency operation.

Axial Loadings.—In the analysis of loads, axial loadings will be considered first. Electrically, the axial loadings of the rotor can be neglected since the rotor is generally set in its magnetic centre so far as axial movement is concerned.

Notation.

A—Axial-flow velocity through eye of impeller.
$\frac{1}{C^2}$—Test head coefficient.
D—Diameter of full-scale pump.
d—Diameter of pump model.
E—Efficiency of full-scale pump.
e—Efficiency of model.
G—Gallon.
G.P.M.—Gallons per minute.
HQ—Head quantity.
N—Number of revolutions per minute.
N.P.S.H.—Net positive suction head.
P—Peripheral eye velocity.
Q—Quantity of flow.
t—Coefficient of velocity through casing throat.
u—Peripheral velocity in impeller.
U.M.P.—Unbalanced magnetic pull.
y—Ratio of outlet area between vanes of impeller to throat area of casing.
η_H—Hydraulic efficiency.
$\frac{1}{\eta_H C^2}$—Newton head coefficient.

* Chief Hydraulic Designer, Harland Engineering Co., Ltd., Alloa.

The pump, however, will give rise to axial thrust as follows :—

(1) If the inlet pressure differs from atmospheric pressure—for example, a suction lift—there will be a thrust, in pounds, away from the motor equal to the area in square inches of the circle corresponding to the sleeve diameter (where the shaft enters the pump) multiplied by the suction lift expressed in pounds per square inch.

(2) If the inlet pressure exceeds atmospheric pressure, a similar thrust will occur, in this case towards the motor.

(3) The pump is fitted with two neck rings. The leakage from the neck ring at the inlet side of the impeller flows into the inlet passage of the pump. The leakage from the neck ring on the driving side of the impeller must be returned to a low pressure region so as to effect reasonable balance. On very small pumps this return is by way of holes in the impeller, but on the pumps of the type under consideration such holes are considered a prejudice to efficiency, and the back neck ring leakage is therefore led either to the inlet passage by way of a separate pipe, or to atmosphere.

There will therefore be a thrust equal to the area of the annulus between the diameter of the neck of the impeller and the diameter of the sleeve multiplied by the pressure difference between the point of disposal of the neck ring leakage and the inlet pressure. This thrust may be positive or negative according to the relative values of the pressures concerned.

(4) The impeller shrouds which are in communication on both sides with the volute of the pump, are theoretically in balance ; in practice an empirical allowance is made to cover casting or fabrication inaccuracies, &c.

(5) The water entering the impeller is turned through 90 deg. This gives rise to a dynamic thrust, in the direction of the motor, varying as the square of the quantity.

In a vertical machine the weight of the impeller and the weight of the rotor give rise to an axial thrust on the shaft and on the bearing.

The ball or Michell bearing on the motor must be designed to carry the algebraic sum of these axial thrusts. In a horizontal machine, however, the axial loading to be carried by the ball or Michell thrust bearing consists only of the impeller thrust loadings described above.

Radial Loadings : Hydraulic.—The impeller is rotating in a casing of scroll form—that is to say, the cross-sectional area of the volute into which the impeller discharges increases progressively from zero to a throat of a certain value. This means that at the best efficiency duty of the pump the flow in the volute is uniform and the pressures round the impeller are reasonably balanced. Radial thrust may therefore be regarded as absent. At duties below the maximum efficiency point there is a radial thrust tending to bend the shaft towards the delivery branch of the pump. At quantities in excess of the maximum efficiency point a similar thrust occurs but in an opposite direction. These thrusts are proportional to the amount of departure from best efficiency point. The determination of these thrusts has been carried out in an extensive research programme by pressure measurements around the scroll and by deflection measurements of the shaft.

Double Volute.—The radial thrust on the casing can be reduced by the provision of a double volute, which aims at providing two thrusts of equal magnitude and opposite direction.

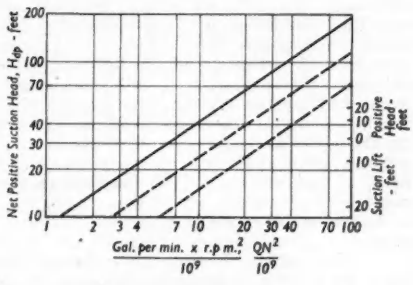
Water Turbines.—For combined water turbo-alternators it is considered that owing to the presence of gates the radial unbalance is small.

Radial Loadings : Electrical.—The electrical unit is subject to an unbalanced magnetic pull (referred to as U.M.P.) at its rotor, tending to deflect the shaft in a radial direction. The unbalanced magnetic pull is generally determined for a standard deflection of 10 per cent of the air gap, and for the purpose of this analysis may be taken as proportional to deflection from the centre of the air gap.

Shaft Deflection.—The combined unit has an impeller rotating in a water gap (neck rings) and a rotor which is turning inside an air gap. It is essential to ensure that under all conditions of working, the impeller neck does not make contact with the stationary neck ring across the water gap and that the rotor does not make contact with its stator across the air gap.

In determining the deflection of the rotor, the forces on the rotor and the forces on the impeller transmitted through the shaft to cause further rotor deflections, must be considered as a whole, with a similar consideration in respect of the impeller.

Critical Speed of the Rotating Element of the Combined Unit.—Any radial loading on the impeller is unaffected by the deflection of the shaft, and therefore such radial loading has no effect on the critical speed which may, for this portion of the rotating element, be determined in the usual manner. In the case of the motor



——— Typical operating line N_{ss} 6200.
– – – – Optimum operating line or typical cavitation line N_{ss} 9000.
- - - - - - - Optimum cavitation line, N_{ss} 12,000.

Fig. 2—Cavitation results with constant N_{ss}

armature, however, the U.M.P. is proportional to the deflection from the magnetic centre. Since centrifugal force is also proportional to deflection from the centre, both these loadings must be added together in the determination of critical speed. It is important, however, that the loadings be added at equal deflections—for example, at unit deflection or, what is more convenient, at the "static deflection" of the rotor under gravity, which is used in the determination of critical speed.

The deflection of the rotor to the "static deflection" point is caused by the sum of the unbalanced magnetic pull at the static deflection and the centrifugal force. The centrifugal force required to produce "static deflection" is lower where unbalanced magnetic pull is present.

The critical speed of the motor portion of the rotating element is therefore lowered, by the

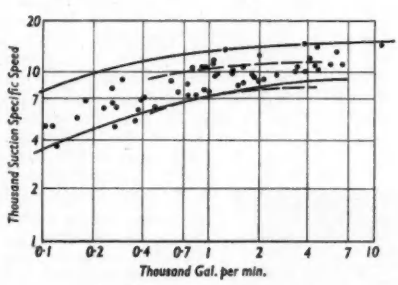


Fig. 3—Cavitation tests

presence of U.M.P., to a value, which is determined by dividing the original critical speed by the square root of the ratio of the rotor weight to the rotor weight minus the U.M.P. at the static deflection. The U.M.P. at the static deflection is proportioned down from the U.M.P. at 10 per cent of the air gap, the usual specified value of the U.M.P.

The critical speed of the complete rotor is then obtained by integration of weights and deflections, using an artificial deflection of the armature portion to simulate the above analysis.

Rigidity of Casing.—The rigidity of the shaft has been considered but the reactions of the load from the shaft must be carried on the casing. It is therefore necessary to ensure that the stationary link between the casing and the motor has ample rigidity for these reactions. Therefore, stiffness ratio in shear of the anchorage of pump and motor and the stiffness ratio in bending are determined with respect to the strength of the shaft.

The Hydraulic Design of Single-Entry Overhung Pumps

The hydraulic design of single-entry pumps is generally similar to that of the double-entry type with, however, the following differences :—

The direct axial entry permits a higher axial-flow velocity so that the single eye is little greater in diameter than the double eye. Depending on the method of attachment of the impeller to the shaft, the inlet blades can be brought well down towards the centre of the impeller, which, together with the high rate of flow results in relatively larger inlet blade angles.

The higher flow velocity and the absence of a shaft on the inlet side of the impeller permits the single-entry type to handle almost as much quantity as the double-entry type for a given suction lift and speed.

Determination of Pump Speed and Dimensions for a Given Duty.—Since the cavitation aspects determine the running speed which, in turn, determines the basic dimensions of the pump, cavitation will first be discussed.

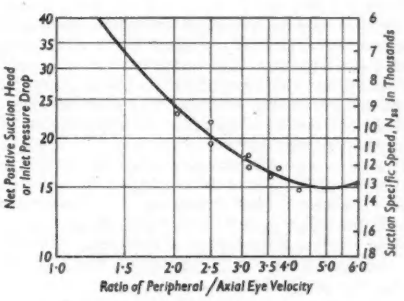
Analysis of Cavitation Characteristics and Determination of Impeller Inlet Dimensions.—The net positive suction head (N.P.S.H.)†, for complete cavitation at best efficiency point is plotted against the product of the gallons per minute and the square of the revolutions per minute, referred to as GN^2. This is shown in Fig. 2. Test points result in a straight line on logarithmic scale, the equation to which is

$$GN^2/N.P.S.H.^{1\frac{1}{2}} = \text{a constant.}$$

This constant is seen to be the square of the suction specific speed, N_{ss}, where,

$$N_{ss} = N\frac{\sqrt{G.P.M.}}{(N.P.S.H.)^{\frac{3}{4}}}.$$

The test lines of best efficiency points can therefore be labelled with appropriate suction specific speeds, namely, N_{ss} 6200 for operation of normal pumps ; N_{ss} 9000 for cavitation of normal pumps ; N_{ss} 9000 for the operational line of special pumps having a large impeller


Net Positive Suction Head or Inlet Pressure Drop
40 35 30 25 20 15 10
6 7 8 9 10 11 12 13 14 16 18
Suction Specific Speed, N_{ss} in Thousands
1·0 1·5 2·0 2·5 3·0 3·5 4·0 5·0 6·0
Ratio of Peripheral / Axial Eye Velocity

To show effect of variation in eye diameter.

Fig. 4—Cavitation test corrected to $GN^2/10^9 = 10$

eye, special inlet design and/or large physical size ; N_{ss} 12,000 for the cavitation line of special pumps. Fig. 3 shows the effect of size on suction specific speed. It will be seen that the safety margin between operation and cavitation is 3000 specific speed units, corresponding approximately to 50 per cent of the cavitation N.P.S.H.

For convenience in referring N.P.S.H. values to site conditions at atmospheric pressure a scale of positive head and suction lift is shown to the right of Fig. 2, the water barometer of 33½ft as N.P.S.H. being equivalent to zero suction lift.

The effect of the larger eye is shown in Fig. 4, where the cavitation N.P.S.H. corresponding to a value of $GN^2/10^9 = 10$ is plotted against the ratio of peripheral eye velocity P to axial-flow velocity A through the eye of the impeller. All test points are therefore corrected to $GN^2/10^9 = 10$ for Fig. 4.

It will be seen that increase in eye diameter for a given duty produces an improvement in N.P.S.H. but that little improvement results

† N.P.S.H. is the difference between the inlet head (including the velocity head in the inlet pipe) and the saturation pressure of the liquid handled.

after $P/A=4$. A scale of equivalent N_{ss} also appears in Fig. 4.

For a given specified quantity and inlet condition, therefore, it is necessary to determine from Fig. 2 the value of the $GN^2/10^6$, from which the maximum permissible running speed can be obtained and a decision made as to whether a normal or special design is involved. The

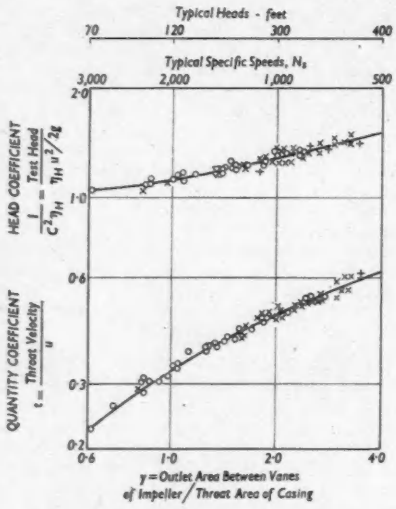


Fig. 5—Test records plotted on basis of area ratio y

running speed must be suitable for the driver, which in the majority of cases is an a.c. electric motor. The value of P/A can now be determined from Fig. 4, from which the actual eye diameter can be calculated.

The Analysis of Tests and the Determination of Pump Dimensions for a Required Head-Quantity Characteristic.—Head and quantity characteristics are analysed empirically as described in Anderson (1947)‡ from which Fig. 5 is taken. Typical specific speeds and typical heads for which various area ratios may be used are shown in the top of Fig. 5.

Fig. 5 can be transposed as shown in Fig. 6, where the ordinates represent the head and the abscissæ represent the quantity. On a proportional basis the rest of the head quantity test characteristics can then be drawn in, so that a family of curves is obtained showing the whole range of pumps between the limits of an impeller of small area in a casing of large throat and an impeller of large area in a casing of small throat. Best efficiency points are shown as circles labelled with the appropriate value of the area ratio y. Since the variable aspect of hydraulic efficiency is eliminated in Fig. 6 the curves are less steep than the test HQ curves.

For a given head the typical specific speed and area ratio can be taken from Fig. 5. Knowledge of the specific speed will permit calculations of the running speed (duly checked by the cavitation limitations described above and arranged to suit the driver). The overall and the hydraulic efficiencies can be determined from the equivalent Reynolds number and the specific speed, N_s 2000, giving the optimum efficiency on single-entry pumps. From the area ratio curve Fig. 5 or Fig. 6 the values of the head and quantity coefficients can then be read off.

The steepness of the head-quantity curve is determined from Fig. 6. Site conditions may, however, demand a steeper curve than is normal for the head and specific speed involved—a lower value of area ratio must therefore be taken from Fig. 5, which will result in a larger impeller for the same duty with larger disc friction and slightly lower efficiency.

The reason for the lower head coefficient with lower area ratio lies in the fact that backward-swept impeller blades are used. The smaller impeller area results in a lower velocity of whirl (since the relative backward flow is greater) and the lower whirl gives a lower head for a given impeller diameter.

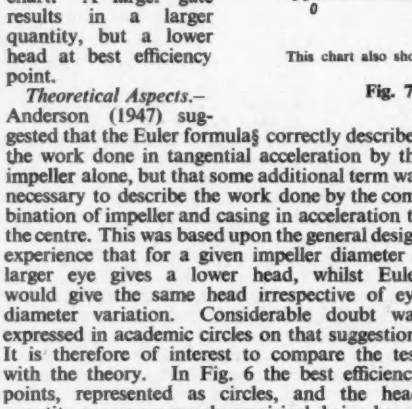
‡ Anderson, H. H., 1947 *Proc. I.Mech.E.*, Vol. 157, page 57, "Centrifugal Pumps—An Alternative Theory."

Effects of Various Dimensional Changes in the Pump.—Fig. 6 may also be regarded as showing the change of performance for change of impeller width where impeller diameter and casing throat area remain unaltered. The impeller width would then be proportional to the value of the area ratio y shown on the chart. Quantity is represented by velocity through the unchanging casing throat, that is, by the coefficient t.

The effect of change of casing throat area is shown in Fig. 7, which is a transposition of Fig. 6, quantity being represented by velocity through the unchanging impeller outlet area, that is, by t/y. Fig. 7 will then represent a gated pump, where the gate area is inversely proportional to the area ratio y shown on the chart. A larger gate results in a larger quantity, but a lower head at best efficiency point.

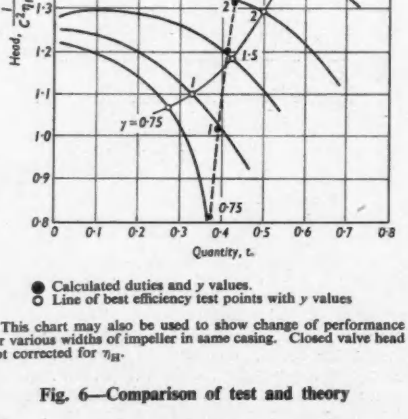
Theoretical Aspects.—Anderson (1947) suggested that the Euler formula§ correctly described the work done in tangential acceleration by the impeller alone, but that some additional term was necessary to describe the work done by the combination of impeller and casing in acceleration to the centre. This was based upon the general design experience that for a given impeller diameter a larger eye gives a lower head, whilst Euler would give the same head irrespective of eye diameter variation. Considerable doubt was expressed in academic circles on that suggestion. It is therefore of interest to compare the test with the theory. In Fig. 6 the best efficiency points, represented as circles, and the head quantity curves are purely empirical, being based on actual tests.

The theoretical values from Anderson (1947) are inserted in Fig. 5. It will be seen that the test and theory agree very closely for the area ratio of 1·5, but that they differ at other values of the area ratio, although the theoretical point occurs on or close to some point on the test characteristics. This transposition of the point of maximum efficiency may perhaps be due to the varying effect of disc friction, which is greater on the lower area ratios since a relatively larger diameter of impeller is required for the same duty. Whilst the theoretical investigation described in Anderson (1947) is open to many objections and is very far from perfect, it has, nevertheless, in the absence of a satisfactory textbook theory, proved of value in assisting the solution of certain pump problems.‖



This chart also shows best efficiency performance for various casing throats with the same impeller, as a gated pump.

Fig. 7—Inverted chart of area ratio and output



● Calculated duties and y values.
○ Line of best efficiency test points with y values

This chart may also be used to show change of performance for various widths of impeller in same casing. Closed valve head not corrected for η_H.

Fig. 6—Comparison of test and theory

§ $h=uw/g$, where h is head, u peripheral impeller velocity, w that part of the whirl of liquid at impeller periphery which is produced by impact of the impeller blade on the liquid, and g is acceleration due to gravity.

General Observations

A large number of the unit construction single-entry pumps have been supplied and have been operated for sufficiently long to indicate their capabilities. High efficiencies have been realised. The greater rigidity avoids mechanical losses, air drawing and shaft damage. Maintenance has therefore been considerably reduced. The simpler flow pattern on the inlet side avoids hydraulic losses, thus giving improved distribution of liquid to the impeller. This type of pump is therefore inherently more efficient than the split-casing type. The improved flow permits the single-entry type to handle almost the same quantity as the double-entry type for a given suction lift and speed.

The greater rigidity has been proved in each case by running the pump dry—a very drastic test indeed which could not be applied to the split casing type. It has also been possible to operate the unit in some circumstances without stuffing-box or packing—a simplification and an advantage where high inlet pressures are concerned.

These pumps are particularly applicable to the high-pressure range of single-stage duties, as the shaft diameter may be made very large. The cover closing the casing is circular in shape and the whole design is simple, providing uniformity and strength. The saving in space and the simplification of layout results in a considerable reduction in size of pump house. This is one of the most important advantages in the new development. In many cases a vertical pump rests directly on the sides of a culvert with a short open suction pipe and ejector priming.

‖ Reference is also made to Anderson, H. H., 1947, *Proc. I.Mech.E.*, Vol. 157, page 85, "Efficiency and Cavitation of Fluid Machines," and to discussion on Pennington, R., 1952, *Proc. I.Mech.E.*, Vol. 1B, page 129, "Centrifugal Pumps in Steam Power Stations."

Earlier Volumes of "The Engineer"

A VERY limited number of bound volumes of THE ENGINEER, including a volume for 1857, have become available and it occurs to us that some firms, libraries or individual readers whose sets of bound volumes are incomplete might like to acquire them. The volumes concerned are listed below. Except where otherwise stated both volumes for the year listed are obtainable.

1857 (January-June only), 1862, 1863, 1865 (July-December only), 1866 (January-June only), 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914 (January-June only), 1915, 1916, 1919, 1920, 1921, 1922 (July-December only), 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1932 (July-December only), 1933, 1935 (July-December only), 1937 (July-December only), 1938 (January-June only).

Anyone interested in obtaining copies of all or any of the above volumes should write to The Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2.

The American Scene

(By Our American Editor)

Golden Jubilee of the International Electrotechnical Commission

THE golden jubilee of the International Electrotechnical Commission (I.E.C.) was celebrated on September 9th as part of the annual I.E.C. meeting, which was held at the University of Pennsylvania in Philadelphia, from September 1st to 16th. The official speakers on this occasion strongly urged an acceleration of international standardisation, as a catalyst to world trade. Speaking before some 800 scientists and electrical engineers from twenty-one countries on the day of the jubilee, Viscount Waverley, who led the British delegation of ninety-six members, pointed out that there may be some temptation to use national standards as a protective device in the interests of the home producer. "This would be a gross misuse of standards and of the knowledge and effort that go to their establishment," he said. "Clearly the demand in world markets for sound well-designed electrical installations will be accelerated if, through greater standardisation, the material and apparatus can have a more general application and can be produced and then maintained at a lower cost. The main contribution of international standardisation, to the lowering of trade barriers, is through standardisation of basic techniques so that the essential qualities or performance of products and equipment can be correctly appraised. There is an opportunity to-day to avoid an unnecessary variety in the insulation levels of equipment for extra high-voltage transmission, by laying down standards for such equipment designed for a limited number of voltage levels. Such work can eliminate difficulties that have hampered international trade in the past."

Another principal address was delivered by Monsieur Pierre J. Ailleret, who led the French degelation and is director of research of Electricité de France. He pointed out that the sheer speed of electrical development and the necessity of keeping up with rapid progress through international contacts had forced the accelerated evolution of electrical standardisation. He felt that interconnection between neighbouring countries, leading to interchangeability of equipment, must be facilitated to a greater extent and pointed out that international standardisation would be furthered if principles of standardisation were taught in technical schools. In his opinion, the publication of booklets on standardisation did not answer the need of young engineers endowed with critical minds. "An honest teaching of standardisation would aim much higher and could actually have a true formative value to engineers," he said.

In a jubilee address on the future of standardisation in the field of telecommunications, Dr Hakan A. Sterky, director-general of the Swedish Communications Board, disclosed that, as a result of the projected installation of a trans-atlantic telephone cable linking Europe and America, plans were already being made for a complete global communication network that would permit intercontinental television and instantaneous telephone conversation with any part of the globe. Dr. Sterky said that studies were now proceeding on how the European telephone network could be linked with networks of Southern and Eastern Mediterranean states. Last year plans were extended to embrace the Middle East and South Asia. An analysis of the present traffic volume and an estimate of the circuits needed had been made and a tentative map drawn, showing the arteries of the complete system. No decisions had been made, however, Dr. Sterky said, as to the technical means which should be used in the project. It was likely that, in addition to carrier systems, submarine co-axial cable systems and wireless links would be useful.

A clear warning that basic research in science has not expanded in the United States since the last war but has remained static or declined, was issued by Dr. Lee A. DuBridge, president of the California Institute of Technology. He felt that Congress had been niggardly in its appropriations to research agencies to the point that to-day it was the responsibility of industry and individuals to support research in basic science. In spite of the widespread public belief that any desired technological product—from pocket radar to cures for cancer—could be purchased at will if sufficient millions were spent, the fact was that knowledge grew slowly. He pointed out that technology could not rest on thin air; it had to be supported by basic research in pure science.

In the evening of the jubilee day a banquet was held at the Bellevue-Stratford Hotel at which the speakers were Mr. A. C. Montieth, the president of the American Institute of Electrical Engineers; Mr. Don G. Mitchell, the chairman of Sylvania Electric Products, Incorporated, and Dr. Harold S. Osborne, the current president of the I.E.C.

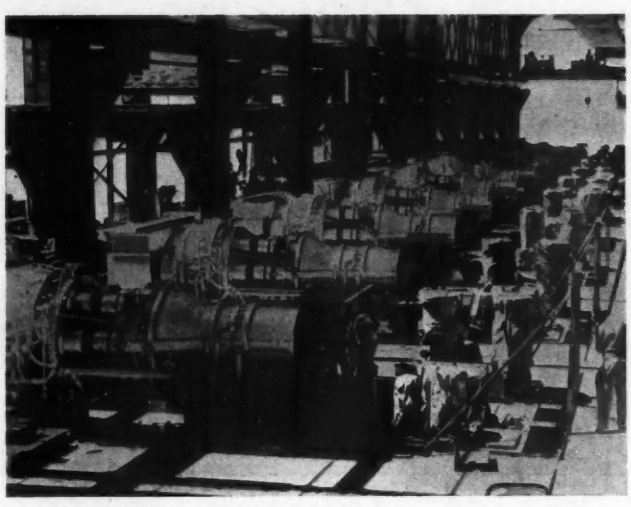
Wide-Flange Beam Rolling Mill

IN view of the recent announcement by Dorman, Long and Co. that it has placed an order for a wide-flange structural section rolling mill with the United Engineering and Foundry Company, of Pittsburgh, it is of interest to recall that just fifty years ago Charles M. Schwab committed the Bethlehem Steel Company to build one of the mills designed by Henry Grey for the rolling of wide-flange structural sections. Grey's own words well illustrate the significance of this bold move: "To Charles M. Schwab belongs the credit for introduction of this mill to the United States, as without his courage and backing the new structural mill and the new structural shapes would in all likelihood have been allowed to lie dormant for many years." Mr. Schwab was convinced of the practicality of the wide-flange sections replacing the built-up sections then made by riveting plates and angles together. Henry Grey's mill for rolling wide-flange sections, which he developed around the turn of the century, had previously been offered to several American companies and turned down. Schwab was the only one who thought the mill practical. He committed the company to build the Saucon Division at a cost of 12,000,000 dollars. The division included ten 60-ton open hearth furnaces; a 46in blooming mill, a 48in roughing and a 48in finishing Grey mill for structural steel shapes; a 40in blooming mill, a 28in standard structural mill, a 28in rail mill, and the required ancillary facilities for these mills.

The financial panic of 1907 nearly stopped the work at Saucon. However, Schwab was determined to keep the new construction going and he persuaded most of the suppliers and contractors to accept notes for their materials and services. Ultimately, both standard beams and special wide-flange sections were rolled on the 48in mill. The special wide-flange sections, known in America as Bethlehem sections, or Grey beams, included three distinct shapes: special "I"-beam sections, girder beam sections, and rolled column "H"-sections. The new Bethlehem section gave the construction industry two major benefits. In the first instance, the distribution of metal between the web and flanges could be readily controlled. This, in turn, made it possible to produce a section having the same strength as a so-called "standard" shape, but up to 10 per cent less weight. Secondly it became possible to roll larger sections than were practical on the standard mills. This fact, coupled with the more ideal distribution of metal, resulted in a considerable saving of fabricating time and labour as well as weight, since sections of comparable useful strength could only be produced by assembling plates and girders.

Large Gas Turbine Pumping Installation

THE photograph reproduced herewith shows the installation of ten 6000 h.p. gas turbines which is said to be the largest single concentration of gas turbines in the world. The gas turbines act as prime movers for pumps which are being used for oilfield repressurisation. Made and installed by The General Electric Company, of Schenectady, New York, the turbines are mounted on a floating platform 7 miles from land, at the Lake Maracaibo oilfield of the Creole Petroleum Corporation in Venezuela. The turbines pump natural gas into the oilfield which is under the lake and the surrounding area. In the Lake Maracaibo oilfield, the underground gas pressure is sufficient to force petroleum crude through wells to the surface without the aid of pumps. But, as the crude is removed, so is the natural gas, and as a result the underground gas pressure is also reduced. The continual reduction of this pressure would eventually require the use of pumps to bring the crude to the surface. To avoid having this happen, a system conceived by the Creole Petroleum Corporation effects the removal of the natural gas from the crude after it reaches the surface and pumps it back into the ground under 2000 lb per square inch pressure. In doing this, the necessary underground pressure is maintained and the viscosity of the crude is lowered. As a result less pressure is required to bring it to the surface.



Gas turbine pumping installation at Lake Maracaibo in Venezuela

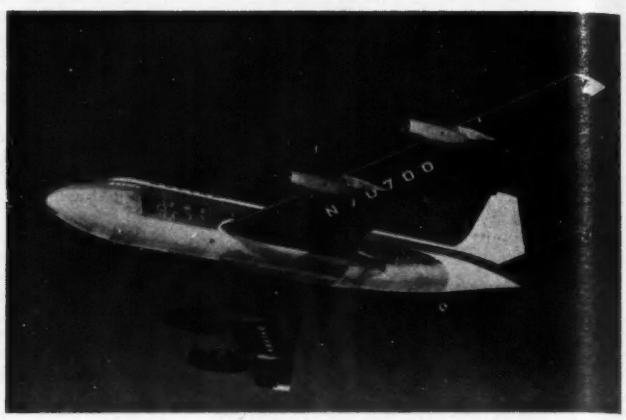
Skyscraper Curtain Wall Erection in New York

A NEW skyscraper in New York furnishes another interesting example of a method of lightweight curtain wall construction which is becoming popular in the United States and which was described in detail in our recent article on the Alcoa Building in Pittsburgh.* A particularly unusual aspect of the curtain wall construction on the Davies Building at 460, Park Avenue, was the unprecedented speed of erection, which has served to illustrate an important advantage of this method of construction. In this case a building operation which would ordinarily have taken from eight to ten weeks under conventional methods of masonry wall construction, was started and completed within the space of a single day. Beginning at 6 a.m. and ending at 4 p.m. on the same day, the Tishman Realty and Construction Company and the General Bronze Corporation of New York transformed a twenty-two-storey bare steel and concrete structural framework into a fully enclosed office building. Two photographs of the building taken, respectively, in the morning and in the afternoon, are reproduced herewith. The entire exterior curtain wall, which consists of 676 two-storey high, prefabricated aluminium wall and window panels, was bolted to steel brackets previously welded to the structural framework. At the appointed time six specially trained installation crews of six men each, working from within the structure without any exterior scaffolding, began simultaneously to erect the panels at six points on the building faces. The panels, which weigh more than 200 lb each, are approximately 4ft 6in wide, 23ft high and ¼in thick. Each panel contains two reversible, vertically pivoted, 6ft high windows, which are designed to rotate to facilitate safe interior cleaning. A geometrical pattern of four facets has been die pressed on the spandrel below each window to provide an element of design as well as to strengthen each panel. To obtain weather tightness, each panel contains a specially designed flange, as an integral part, which interlocks with adjoining panel flanges, thus completely eliminating caulking. Stainless steel weather stripping around each window will give further protection from the weather and will also ease the strain on the air-conditioning system of the building.

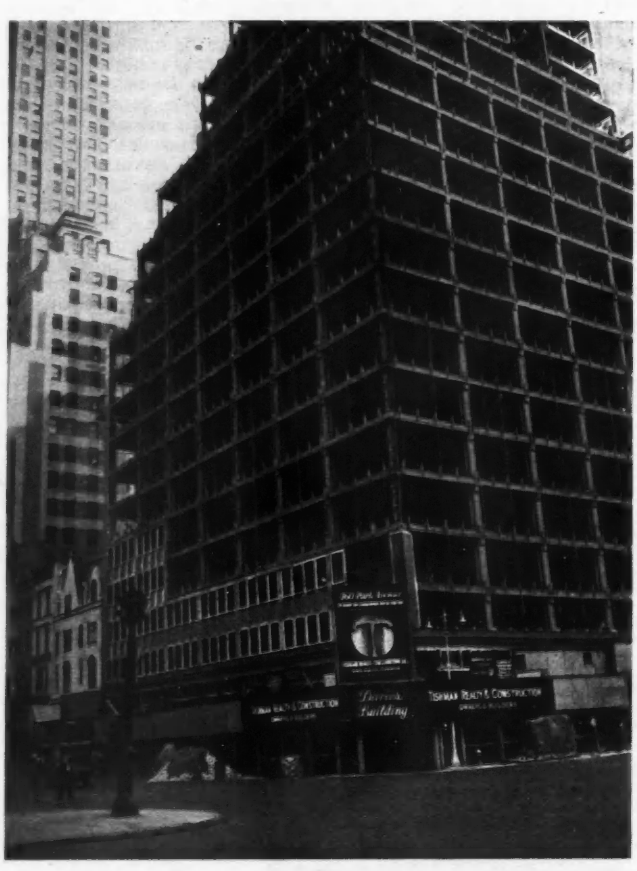
* THE ENGINEER, July 23, 1954, page 138.

Maiden Flight of Four-Engined Jet Aircraft

THE accompanying illustration shows the Boeing " 707 " four-engined jet " Stratotanker " tanker-transport aircraft on its recent maiden flight. This prototype unit is essentially a military model, which is equipped with cargo doors and provisions for the installation of cargo tie-downs and aerial refuelling equipment. However, present plans call for the aircraft to be demonstrated both to the military services and to commercial airlines. Its development represents a private investment by the Boeing Airplane Company of more than 15,000,000 dollars. The swept-back wings of the " Stratotanker " have a span of 130ft. Its length is 128ft and tail height 38ft 3in. It has a gross weight of 190,000 lb and is powered by four 10,000 lb thrust Pratt and Whitney " JT–3P " turbo-jet engines. The engines are mounted individually in the suspended pods which have come to characterise Boeing jet aircraft. It is said that as a multi-purpose tanker-transport aircraft for the armed Forces, the Boeing " 707 " will make possible greater range, striking power and mobility. With a cruising speed in the neighbourhood of 550 m.p.h., the new aircraft, when used as a commercial airliner, will be capable of regular trans-continental United States non-stop flights in less than five hours, and non-stop New York-to-London schedules of less than seven hours. Depending on range and payload requirements, the Boeing " 707 " will carry from eighty to 130 passengers, cruising at an optimum operational altitude between 30,000ft and 40,000ft. The aircraft was flown above 42,000ft and at speeds of more than 550 m.p.h. on its third test flight, only two days after the maiden trip. The new aircraft will be called " Stratotanker " in its military version and " Stratoliner " in its civil version. It is the third large, swept-wing, high-speed heavy jet aircraft to be built by the Boeing Company.



Maiden flight of Boeing 707 " Stratotanker "



Commencement of curtain wall erection on Davies building in New York (6.30 a.m.)

Completion of curtain wall erection on Davies building in New York (4 p.m.)

Industrial and Labour Notes

Overseas Trade

Exports of United Kingdom goods in the month of September were valued at £210,400,000. The Board of Trade says that this was a little higher than in August, but that both months are normally affected by holidays ; the effect of the London dock strike is not reflected in the September figures. In the third quarter of this year, exports averaged £221,000,000 a month, which was over £9,000,000 a month more than in the corresponding quarter of last year, and about the same as the average for the third quarter of 1951. Throughout this year, however, the rate of improvement has declined in successive quarters as compared with last year ; the rates of increase over the corresponding quarters of 1953 being 7½ per cent in the first quarter, 6½ per cent in the second quarter, and 4½ per cent in the third quarter. For the nine months as a whole, exports were more than 6 per cent in excess of those from January to September, 1953.

In a statement reviewing the trade situation, the Board of Trade comments that, with only minor price changes during the period, it is expected that the volume of exports in the third quarter of this year will prove to have been slightly less than in the two preceding quarters, thus reflecting the seasonal effect of industrial holidays. For the nine months, however, the volume was probably about 8 per cent greater than in the corresponding period of 1953 and greater than in any preceding comparable period. Between the second half of 1953 and the first half of this year, engineering products contributed most to the improvement in United Kingdom exports, although between the first two quarters of this year metals and " other manufactures " showed a rising tendency while engineering products and textiles moved in the opposite direction. These trends continued into the third quarter, when exports of " other manufactures " were higher than in any quarter since January-March, 1952, and metals also showed a considerable improvement. Lower exports of engineering products and textiles, however, offset these gains and more than accounted for the slight fall generally in exports in the third quarter compared with the first half of this year.

The Board of Trade suggests that the reduction in engineering exports in the third quarter probably resulted mainly from seasonal factors such as industrial holidays and the summer slackening in demand for some items. Engineering exports in the third quarter were at an average value of nearly £82,000,000 a month, which was about 5 per cent below the monthly average in the first half of this year. The decline in engineering exports occurred mainly in machinery other than electrical, shipments in the third quarter falling to £33,000,000 a month, or more than 6 per cent below the average in the first half of the year. The Board of Trade says that the U.S.A. and Canadian markets were chiefly affected, together with some European markets, but machinery exports to Australia remained steady and New Zealand took more. The reductions were spread over different classes of machinery, including mechanical handling equipment, textile machinery, air-conditioning and refrigerating machinery, and aircraft engines. Exports in the electrical machinery division, which were high in the first quarter of the year, have been declining since.

Industrial Development Scheme

We were recently invited to a press conference at which Mr. C. A. Samuels, chairman of C.A.S. (Industrial Developments), Ltd., explained the method developed by his company, which was formed in 1949, for the direction, design and construction of industrial development schemes, such as new factories. We have mentioned before in THE ENGINEER that there is a school of thought in the civil engineering industry, particularly, which maintains that design as well as construction should be competitive. Some steps in this direction have been taken by C.A.S., Ltd., but its method covers the legal and administrative aspects of a new scheme, as well as the technical ones, and does not seem to cut across professional ethics in design.

Briefly, C.A.S., Ltd., sets out to provide a factory, to given specifications, in an area selected by its client, in return for an agreement that the client will pay a stated rent for the completed project, generally on a sixty-year lease. The firm then buys the land, does the design work and finances the project. Thus, it carries with its organisation consulting professional men—architects, structural, mechanical and electrical consultants, quantity surveyors, solicitors and real estate consultants. This team of designers deals with C.A.S. (Industrial Developments), Ltd., and its subsidiary C.A.S. (Contractors), Ltd. The latter firm sub-contracts the constructional work. An aim of the method has been to eliminate as many variables as possible in the bills of quantities, so that apart from variations in works below ground level, and in costs of labour and materials, a firm price can be quoted.

Trade Unions and Industrial Relations

Among the papers read at the European Management Conference, which was held at Torquay last week, was one dealing with the British trade union approach to industrial relations. This paper was presented by Mr. Tom Williamson, general secretary of the National Union of General and Municipal Workers, and chairman of the British Productivity Council.

In the course of his paper, Mr. Williamson said that, although there was friction from time to time, industrial relations in the United Kingdom at present were relatively harmonious. If the amount of working time lost through disputes in the second half of 1954 was no greater than that lost in the first half, the total for the year would be the lowest since the war, and spread over the whole of the working population it would not amount to more than thirty minutes per worker. Naturally, Mr. Williamson added, one would like to see that modest figure reduced, but the present situation was in vivid contrast with the state of affairs twenty or thirty years ago.

After reviewing trade union activities in the inter-war years, Mr. Williamson went on to talk about developments in trade union policy since the second world war. In that period, he said, there had also been changes in the industrial, political and social background against which those developments must be viewed. About wage negotiations, Mr. Williamson's comment was that two factors—the cost of living and the relative movements of the incomes of other sections—had a profound influence on the trade union attitude to the existing overall level of wages. Any development which threatened the real value of wages, such as a rise in the price level, or which threatened to reduce the wage-earners' share of the national income, as, for example, disproportionate increases in dividend payments, inevitably produced a reaction on the part of the unions which was aimed at redressing the position. Moreover, the trade unions claimed their fair share of the benefits of rising productivity, both as producers and consumers. Nevertheless, Mr. Williamson asserted, the evidence of the post-war years was that, so long as the standard of living of the working people was protected and reflected increases in productivity, and provided they were not provoked by unrestrained action on the part of others, trade unions could be relied on to act with restraint.

Another matter upon which Mr. Williamson commented was industrial efficiency. He said that the first " responsibility " under that heading was the maintenance of industrial discipline. There was a moral obligation to give good service for good wages, for if it was insisted that a good day's work was worth a good day's pay, the converse—that a good day's pay was worth a good day's work—could not be escaped. The second responsibility concerned with industrial efficiency was, Mr. Williamson observed, the elimination of outmoded restrictive practices. That, he felt, was often a difficult and delicate problem impinging upon inter-union relations. Many so-called restrictive practices arose from the craftsman's anxiety to preserve what he regarded as the traditional rights of his craft, and others dated from the time when it was easy to " work oneself out of a job." In either case, Mr. Williamson commented, elimination involved overcoming prejudices and fears which had been ingrained by years of unhappy experience.

Industrial Development in Wales

The ninth annual report of Government action in Wales and Monmouthshire has been published this week by H.M. Stationery Office (Cmd. 9287, price 1s. 6d.). It deals with the year ended June 30th last, and says that both in the basic and the manufacturing industries there were increases in the total numbers employed. By the autumn of 1953, the report continues, the tinplate industry had recovered from the recession of trade which had set in early in that year, and in the sheet steel industry and at the blast furnaces there was also increased employment. The total number of workers on colliery books in Wales, however, was lower, and in the ship repairing yards employment fell away under the effect of the decline in demand which was felt by the industry generally.

In the South Wales coalfield, the report notes, there were fewer men in the pits last year than in the year 1952–53, but the production of saleable coal showed a slight increase. Output per manshift at the coal face was a little lower, but on account of the redistribution and reorganisation of labour on the surface and underground, output per manshift overall remained practically the same as in the preceding year. Recruitment to the coal mining industry, both of juveniles and adults, declined in 1953, and wastage of labour increased. The report goes on to say that work has started on the two new collieries at Cynheidre and Abernant, which will within the next ten years begin to make available vast quantities of anthracite. The reorganisation of the Ffaldau colliery has been completed, and the other large reconstruction schemes in South Wales have continued to make good progress, as have also the North Wales schemes, including the very substantial alterations at Point of Ayr.

The report records that in the engineering industries there were isolated instances of redundancy, though, on the whole, the employment position remained satisfactory throughout the year. Machine tool manufacturers found their markets somewhat quieter, but electrical engineering firms continued to make good progress in spite of rising foreign competition. Activity in the aircraft industry is stated to have been well maintained.

Coal Output

Last week, the saleable output of coal from the deep mines in Great Britain amounted to 4,394,000 tons, and from opencast workings 197,400 tons, giving a total for the week of 4,592,300 tons, which was about 8,000 tons less than in the comparable week of last year. In the first forty-two weeks of this year, ended October 23rd, coal output totalled 180,169,300 tons, thus exceeding output in the corresponding period of last year by about 1,289,000 tons.

The Minister of Fuel and Power, Mr. Geoffrey Lloyd, said in the House of Commons last Monday that coal stocks were now rising satisfactorily. He estimated that by the beginning of the " coal winter " on November 1st, distributed stocks would amount to between 17,500,000 tons and 18,000,000 tons, compared with just over 18,000,000 tons last year. That was 2,000,000 tons higher than in any other post-war year except 1952, which was altogether exceptional. In addition, the Minister stated, coal imports would be coming into the country at the rate of about 500,000 tons a month during the whole of the winter.

Notes and Memoranda

Rail and Road

YORKSHIRE ROAD IMPROVEMENTS.—On Monday last the Minister of Transport and Civil Aviation received a deputation from the West Riding of Yorkshire about road improvements. The case was presented to the Minister for the following improvements: Doncaster by-pass; rebuilding of weak bridges on the Great North Road to avoid extensive traffic diversions; other road improvements and diversions on the Great North Road; and the planning and preparation of an east-west route across the county. The Minister received statistical and other information concerning the traffic position and undertook to consider fully the matters which had been put before him.

DIRECTION INDICATORS ON MOTOR VEHICLES.—The Minister of Transport and Civil Aviation has announced that he is reviewing the question whether the fitting of direction indicators and stop lights on motor vehicles generally should be made compulsory. At present these items of equipment are not compulsory, though, if fitted, they must comply with certain legal provisions. In the report of the former Committee on Road Safety, published in 1947, it was recommended that the fitting of direction indicators and stop lights on motor vehicles should be made compulsory subject to suitable exemptions. It was not possible at that time to implement the committee's recommendation, partly because of economic circumstances and partly because of technical difficulties. The Minister has issued a circular to representative organisations of road users informing them that he now wishes to review the question and asking for their comments.

RETIREMENT OF MR. F. A. A. MENZLER.—The London Transport Executive has stated that Mr. F. A. A. Menzler, its chief development and research officer, is to retire on November 6th. Mr. Menzler, who is sixty-six, was originally in the Civil Service, latterly in the Government Actuary's department. While in that department he was secretary of the Permanent Consultative Committee on Official Statistics and a member of the statistical committee of the Medical Research Council. He resigned from the Civil Service in 1929 to take an appointment in the personal office of Lord Ashfield, then chairman of the Underground group of companies. In 1930 he was appointed actuary to the group and later to the London Passenger Transport Board, a position he held until he was made chief financial officer of the Board in 1939. He became London Transport's first chief development and research officer when the post was created in 1945. As chief development and research officer Mr. Menzler was responsible for the review of general social and economic trends and for research upon their reactions on the passenger transport system of London. In these fields he had previously worked closely with Mr. Frank Pick. The first London Travel Survey was undertaken under his direction in 1949. He was also responsible for the general oversight of the Executive's scientific services. In this connection he was closely associated with the development of operational research methods as an aid to efficiency in London Transport. He was appointed in 1948 as the chairman of London Transport's research and development committee, of which the four chief engineers and the director of research are members. The committee has, among other things, the general duty of reviewing current scientific research and technical development and of stimulating and co-ordinating the scientific research and experimental work of London Transport.

Air and Water

GRAIN HANDLING PONTOON.—We are informed that the Goole Shipbuilding and Repairing Company, Ltd., has completed the grain handling pontoon "M.O.T. Elevator No. 6" and has launched a similar pontoon, "M.O.T. Elevator No. 7," for the Ministry of Transport, London.

SHIPBUILDING CONFERENCE.—At the annual general meeting of the Shipbuilding Conference held in London on October 14th, Mr. J. W. Elliot, chairman of Swan Hunter and Wigham Richardson, Ltd., and Sir James McNeill, deputy chairman and managing director of John Brown and Co. (Clydebank), Ltd., were re-elected president and vice-president respectively for 1954–55.

INSULATION FASTENINGS.—We are informed that the method adopted for the attachment of Fibreglass sheeting, known as "Navyboard," to decks and bulkheads for insulation purposes has been developed by Crompton Parkinson, Ltd., in co-operation with Fibreglass, Ltd. The method consists of stud welding $\frac{1}{8}$in diameter plain pins, having flat slightly chamfered outer ends, to the plate work, impaling the insulation on the pins and securing by polythene capped "speed fixes" consisting of perforated spring steel washers, having two teeth, which can be pressed over the pins.

Miscellanea

WATER STORAGE.—The Minister of Housing and Local Government has stated, in a written Parliamentary reply, that the total storage capacity of water undertakings in England and Wales increased from about 119,100 million gallons in 1952 to about 304,700 million gallons in 1953.

"ORIGINEERING."—The first in a series of six publications entitled "Origineering," issued by the Lincoln Electric Company, Ltd., Welwyn Garden City, Herts, is intended for people in the management, design and production fields and gives examples of how careful planning cuts costs.

INDUSTRIAL ACCIDENTS.—The Ministry of Labour has published through H.M. Stationery Office its twenty-first bulletin entitled *Accidents*. It describes recent industrial accidents in factories and docks and in building and constructional operations and sets out useful suggestions as to how similar accidents in industry might be prevented.

PORTABLE STEAM ENGINE AND BOILER.—In our issue of October 1st, page 454, we described a portable steam engine and boiler developed by Ricardo and Co. (1927), Ltd., for the National Research Development Corporation. In a reference to a 2½ h.p. engine taking steam at 150 lb per square inch we gave its steam consumption as "30 lb per hour." This should have read "30 lb per horsepower-hour."

COAL PROSPECTING AT RIVELIN VALLEY.—The Parliamentary Secretary to the Ministry of Fuel and Power has stated that preliminary pitting and drilling work by the National Coal Board has proved the existence of good quality coal in the Rivelin Valley, Sheffield. It is, however, too early yet to determine whether coal is present in sufficient quantities to justify the preparation of working proposals. Further drilling will be necessary before that question can be considered.

GREASE GUNS.—We are informed by Lawrence Edwards and Co., Commercial Buildings, Oxford Street, Kidderminster, that it is now making two new grease guns under the trade name "Maxigun." The larger of these guns is of lever-operated design and has a capacity of 16 oz; the smaller of the "pom-pom" or push type holds 4½ oz of grease. The large gun has a rigid tube fitted with a hydraulic connector and is tested to withstand pressures of up to 9000 lb per square inch.

MANAGEMENT CONFERENCE.—The Brush Group has recently held its annual management conference, at which the main theme was "Organisation for Selling." More than 100 delegates, coming from the Group's factories and headquarters, and including directors, executives and foremen, met together to share their problems and air their views. The conference emphasised the importance of ensuring that the customer was kept fully informed of the position of his order from the time he first placed it, and that his interests were paramount.

BENCH WASHING PLANT.—A small hand-operated washer for use on the bench has been put on the market by Alfa-Laval Company, Ltd., Great West Road, Brentford, Middlesex. A development of the same firm's "Parawash" equipment, the "Paraminor," is designed to hold 2 gallons of paraffin, white spirit, or cold cleanser. Alternatively, the machine can be used to apply oil or rust preventatives to new parts before assembly or storage. The pump is stated to have a delivery of up to 300 gallons per hour at 20 lb per square inch. The head is adjustable, giving anything from a fine spray to a solid jet, and an efficient and easily maintained filter is fitted.

PNEUMATIC REMOTE CONTROL EQUIPMENT.—We are informed by Telektron (Great Britain), Ltd., 7, Chesterfield Gardens, London, W.1, that it has acquired the manufacturing licence for this country and the Commonwealth of the Swedish "Telektron-Hard" pneumatic remote control system. In this equipment a toothed wheel keyed to the shaft to be rotated is turned in the required direction by spring-loaded ratchets, actuated by diaphragm air motors. With this equipment the speed of rotation varies with the load, and as the load increases the speed is reduced as the torque is increased. The torque applied is approximately equal in pound-feet to the applied air pressure in pounds per square inch.

ACHEMA XI—EXHIBITION AND CONGRESS, 1955/CONGRESS OF EUROPEAN FEDERATION OF CHEMICAL ENGINEERS, 1955.—The 1955 Congress of the European Federation of Chemical Engineers, and the Achema XI—Chemical Plant and Apparatus Exhibition and Congress, are both to be held in Frankfurt a.M. from May 14 to 22, 1955. Comprehensive information regarding these events is to be published by Dechema, at a Press conference on November 10th, which will also deal with the Corrosion Conference and Dechema annual meeting to be held in Frankfurt from November 11th to 13th. The address of Dechema-Deutsche Gesellschaft für Chemisches Apparatewesen is Frankfurt/Main-W.13, Postfach.

OFFICE MACHINERY.—Office machinery exports during the first three-quarters of this year reached a level of £9,024,764, or over £1,000,000 more than during the corresponding nine months of 1953. The Office Appliance and Business Equipment Trades Association says that the principal importing countries were Australia, U.S.A., South Africa, and Canada. Total deliveries of typewriters to home and export markets during the first seven months of this year amounted to 131,522, to a value of £5,288,000, as against 94,339 machines valued at £3,820,000 in the same period last year. Deliveries of accounting and similar machinery during the same period amounted to £9,651,000, which was £1,400,000 more than in the comparable period of 1953.

COAL SALES ORGANISATION.—The National Coal Board states that its new regional sales organisation is to come fully into operation on November 1st. From that date the Board's sales manager in each region will be responsible for the sale of all coal (with certain exceptions) consumed in that region. Therefore buyers in a region will need to deal with only one Coal Board office, irrespective of the number of coalfields from which they draw supplies. The sales offices will deal with all inquiries, make contracts, give the necessary follow-up service, and in general provide the Board's principal contact with buyers. Consumers will, however, remain free to choose their own distributive channel. Contracts negotiated by Coal Board divisions before November 1st for supplies after that date will be carried out by the appropriate regional sales office.

FARADAY HOUSE OLD STUDENTS' ASSOCIATION.—The annual dinner of the Faraday House Old Students' Association was held at the Savoy Hotel, London, on October 22nd. Mr. J. Eccles, president of the Institution of Electrical Engineers, who proposed the toast of "Faraday House," spoke of the progress that had been made since Faraday House opened in 1890, with seven students and two teachers, including Dr. Alexander Russell, who was the senior lecturer. Mr. Eccles made a plea for simplification, wherever possible, in the methods of teaching, and in the use of units, to help students to stay the course and master the more complex technologies employed by modern industry. Dr. W. R. C. Coode Adams, principal of Faraday House, replied. Other speakers were Mr. A. N. Irens, immediate past-president of the Faraday House O.S.A. and Mr. A. R. Cooper, controller of the North West, Merseyside and North Wales Division of the B.E.A. The toast of "The Chairman" was proposed by Mr. J. W. Bailey and Mr. E. L. Gethin responded.

ASSOCIATION OF ENGINEERING DISTRIBUTORS, LTD.—On Tuesday last the eleventh annual general meeting of the Association of Engineering Distributors, Ltd., was held in London. When the business of the meeting was concluded a paper was presented by Mr. L. W. Scott Alter, the president and general manager of the American Tool Works Company, on "The Distribution of Engineers' Tools and Equipment in the U.S.A." Following the meeting a luncheon was given with the new president, Mr. J. P. Lister, in the chair. At this luncheon the toast of "The Association" was given by Viscountess Davidson, who spoke of the wide scope of the association and the useful work its members did as intermediaries between the manufacturers and users of engineers' tools. In his speech Mr. Lister said that the association had for one of its aims the improvement of its services to industry and referred to the matter of discounts between makers and distributors. Certain anomalies existed in this connection, and he, for one, would like to see a return to pre-war trading terms. A later speaker, Mr. Alex Dormer, spoke of the dangers of price cutting by distributors and the difficulties which could eventually arise with such practices.

Personal and Business

MR. D. A. SMITH has been appointed assistant sales manager of Winget, Ltd.

MR. R. G. SMERDON has been appointed a member of the Transport Arbitration Tribunal.

MR. K. A. MACLEAN has been appointed head of the fabricating division of Aluminium Laboratories, Ltd., Banbury.

BABCOCK AND WILCOX, Ltd., states that its Cardiff office has been moved to 26, High Street, Cardiff (telephone, Cardiff 29366).

THE BOARD OF TRADE announces the appointment of Mr. H. Douglass to the advisory council of the Export Credits Guarantee Department.

GEORGE ELLISON, Ltd., Perry Barr, Birmingham, announces the appointment of Mr. B. L. Scott as engineer-representative in Northern Ireland.

MR. DONALD BASTOW, M.I.Mech.E., has been appointed technical assistant to the managing director of Metalastik, Ltd., Evington Valley Road, Leicester.

DR. R. BEECHING has been appointed chairman of the metals division of Imperial Chemical Industries, Ltd., in succession to Mr. C. E. Prosser, who is retiring. Dr. Beeching will take up this appointment on February 1st next.

MR. EWEN H. SMITH, of David Rowan and Co., Ltd., has been re-elected chairman of the National Association of Marine Engine Builders. Mr. P. L. Jones, of Swan, Hunter and Wigham Richardson, Ltd., has been re-elected vice-chairman.

THE MINISTRY OF SUPPLY states that Mr. H. C. B. Thomas has been promoted to the rank of deputy chief scientific officer and has been appointed head of the mechanical engineering department of the Royal Aircraft Establishment, Farnborough.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that its Bedford depot is to be closed down on November 1st. A new depot, in charge of Mr. W. H. Spillman, is to be opened on the same day at 81, Dumfries Street, Luton, Beds (telephone, Luton 6866).

COLONEL J. F. TODHUNTER, has relinquished his appointments as director and general manager of Murex Welding Processes, Ltd., for health reasons. He is being retained as a consultant to the company. Mr. J. M. Willey has been appointed general manager.

THE BRUSH GROUP, Ltd., announces the following appointments:—Mr. S. Webster, deputy managing director of the National Gas and Oil Engine Company, Ltd.; Mr. B. D. Giordán, managing director of Bryce Berger, Ltd.; Mr. D. G. Hawkins, assistant group sales director; Mr. R. G. Hooker, general works manager and director of Brush Electrical Engineering Company, Ltd.; Mr. B. R. Cant, works manager of J. and H. McLaren, Ltd.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has reorganised its companies into four groups: B.T.H. group, Ediswan-Hotpoint group, M-V.E. group, and Overseas group. The following are the group managing directors:—Mr. E. H. Ball (B.T.H.), Mr. A. N. E. McHaffie (Ediswan-Hotpoint), Dr. C. Dannatt (M-V.E.), and Dr. I. R. Cox (Overseas). As part of the reorganisation, Mr. G. A. Cheetham has joined the board of Metropolitan-Vickers Electrical Company, Ltd. He continues as managing director of Ferguson Pailin, Ltd.

British Patent Specifications

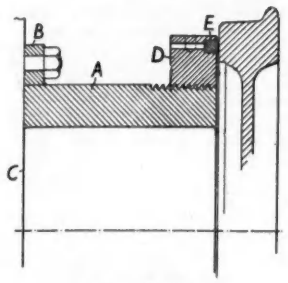
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

MACHINE TOOLS

715,467. August 7, 1951.—LATHE DRIVERS, John Baker and Bessemer, Ltd., Brinsworth Iron and Wheel Works, Rotherham, and Albert Barker, Rose Vale, Warren Vale Road, Swinton, Yorkshire.

The invention relates to lathe drivers and has particular, although not exclusive, reference to lathe drivers used for the machining of the treads of the wheels of railway rolling stock. It is an object of the invention to provide an improved method of transmitting torque. Referring to the drawing, it will be seen that the forged steel annulus *A* has a flange *B* at one end, and is secured concentrically to the face plate *C* by bolts. Both face plates of the wheel lathe are similarly fitted. The outer ends of each annulus



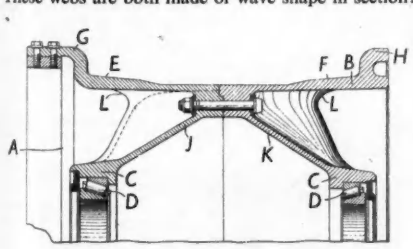
No. 715,467

have a buttress thread and carry the annular members *D* which are an easy fit on the screw thread. These members are drilled at several points round their surfaces to accommodate driving bits *E*. When setting up the lathe for machining the treads of a pair of wheels, the members *D* are screwed back slightly and with the axle in position they are then rotated to bring the driving insets into contact with the face of the wheel. The lathe is then started and the machining commenced. Initially, the pressure of contact between the driving insets and the wheels need not be great. Directly the resistance imparted by a cutting tool machining the wheel treads causes the rate of rotation of the wheels to slow down the slip between the wheels and the driving bits causes the annular members *D* to rotate slightly and this increases the pressure of contact between the insets and the wheel. Thus, as the resistance caused by machining increases, so will the pressure of contact. The pitch of the thread is quite coarse to avoid damaging the wheels.—*September* 15, 1954.

AERONAUTICAL ENGINEERING

716,225. November 20, 1952.—METAL AIRCRAFT WHEEL, Wingfoot Corporation, 1144, East Market Street, Akron, Ohio, U.S.A.

The invention relates to metal wheels and particularly to aircraft wheels. As the drawing shows, the wheel comprises two wheel sections *A* and *B* of substantially the same but reversed constructions. Each of the wheel sections includes a hub *C* within which suitable bearing means *D* are positioned. Likewise, each wheel section includes a rim section *E* and *F*, with flanges for the fitting of tyres. The wheel sections have conical webs *J* and *K*, formed integrally with the associated hub and rim sections. These webs are both made of wave shape in section.



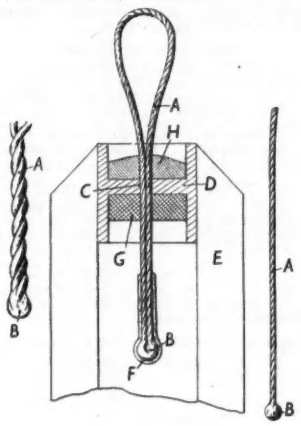
No. 716,225

The drawing clearly shows that the waves or corrugations provided in the web, become both deeper and wider as the web approaches the rim section. The actual connection between the web and the rim section is made by means of a filleted connecting section *L* that doubles back axially toward the outer edge of the rim and the web *K* connects to the rim section in a similar manner. The connection of the wheel sections together is by use of interfitting bosses formed integrally on radially inner portions of the rim section.—*September* 29, 1954.

MINING ENGINEERING

715,894. August 17, 1951.—FRICTION IGNITING DEVICE, Societe Alsacienne D'Explosifs et D'Applications Chimiques, Richwiller (Haut-Rhin), France.

The invention relates to a non-metallic friction device for the ignition of explosives or other inflammable products, applications of which may be the detonation of mines and other explosive contrivances, or the ignition of fuses. As shown in the drawing, the flexible cord *A*, formed in a loop and terminating in a bead *B*, is engaged at *C* in a hole pierced in the centre of an element *D* forming part of the body of the igniting device, shown diagrammatically at *E*,



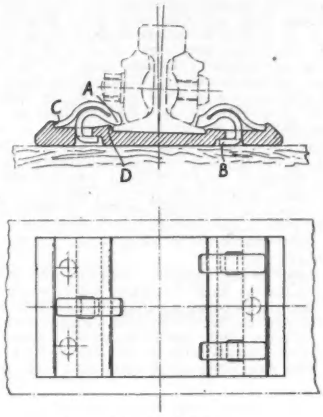
No. 715,894

and intended to be arranged on the fuse which is to be ignited. The beaded end of the cord is sheathed by a coating *F* of an abrasive paste which comprises, for example, a basis of powdered glass, or an inflaming paste, or a mixture of the two. A suitable formula for this paste is powdered glass, 50 grammes; potassium chlorate, 20 grammes; gum, 7 grammes; water, 23cc. In the element *D* there are housed a capsule *G* of inflaming material through which the cord passes, and a sealing lining *H*, of a composition which renders it possible to regulate at will the mechanical resistance to the pull exerted on the cord. An example of a suitable composition for the inflaming capsule is: antimony sulphide, 40 grammes; potassium nitrate, 45 grammes; mercury fulminate, 10 grammes; gum, 5 grammes. The cord may be formed by a single piece of cord, looped or by a twist of one or more smooth threads.—*September* 22, 1954.

RAILWAY ENGINEERING

715,866. July 30, 1952.—THE SECURING OF RAILWAY RAILS, The United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, and Bernard Grundy Mason, of the Workington Iron and Steel Company, Moss Bay, Workington, Cumberland.

The invention relates to the securing of railway rails to sleepers or to bearing plates attached to sleepers. Referring to the drawing, there is shown a metal bearing plate secured to a sleeper. The upper surface of the bearing plate is recessed for the accommodation of the lower flange of a rail, and has a pair of parallel continuous ribs extending across the width of the plate. The rail is secured to the bearing plate by bifurcated or laminated spring clips of steel. Each clip is doubled back upon itself and shaped to provide a nose piece *A* of double thickness, one extension from the lower part of the nose is bent to form a toe *B*, and the other a tail piece *C*. Each clip is received and located in the bearing plate by a hole in a longitudinal groove and by an upstanding rib. The toe of the clip passes through the hole and exerts a vertical pressure against the underside of the groove and a horizontal pressure against the wall of the hole. The tail of the clip bears against the rib, whilst the double-backed nose of the clip bears against the rail flange. When assembling the fastening the toe of the clip is inserted in the hole with the clip at right angles to its final position, after which the clip is rotated by means of a suitable tool. During rotation the nose rides up an inclined surface of one of the rail flanges, the bearing plate surface being so inclined that it forms a more or less continuous plane with the inclined surface of the rail flange. In this way the clip is gradually opened, so that its pressure increases to a maximum in its final position at which the tail bears hard against the rib and is locked in that position due to the square end of the tail. Alternatively, the inclined surface of the



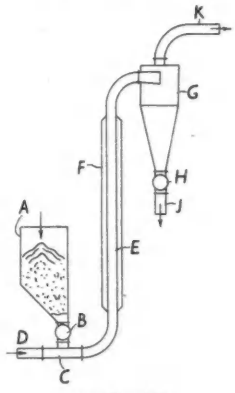
No. 715,866

bearing plate could be higher at its highest extremity than the edge of the rail flange. In this way the spring clip will attain its maximum pressure when its nose reaches the point *D* and as the clip is turned to its final position the nose will drop on to the rail flange, thus providing an added locking effect. Several modified designs of clips for different forms of sleepers are shown in the specification.—*September* 22, 1954.

FUEL PREPARATION

716,273. December 18, 1950.—THE DISTILLATION OF COAL, Hermann Bücher and Herbert Luckow, Kreuznacherstrasse 29, Frankfurt am Main, Germany.

The invention relates to a process for the distillation of coal in which finely divided coal is continuously introduced, at the lower end of a substantially vertical distillation chamber, in co-current into a stream of superheated steam and heated to distillation temperature and, when the distillation is complete, the individual distillation products are separated in



No. 716,273

the known manner. Referring to the drawing, the finely divided coal for treatment is housed in the hopper *A*. By means of the bucket wheel *B* at the lower end of the hopper it is transferred to the injection pipe *C*. Superheated steam passes through the connecting pipe *D* into the injection pipe *C* and from there into the distillation chamber *E*, the straight portion of which is provided with heating elements *F*. The superheated steam carries the entrained coal particles up through the reaction chamber during which operation under the influence of the superheated steam and the heating elements distillation takes place. On account of the small size of the individual coal particles and their uniform envelopment by the stream of superheated steam, this operation takes place fairly quickly, easily and uniformly. It may be advantageous to preheat the coal dust before supplying it to the injector. When the distillation is complete the mixture of superheated steam, gaseous hydrocarbons, tar vapours and coke particles arrives in the separator *G*. The separator separates the solid coke particles which sink down and are passed by means of the bucket wheel *H* to the outlet pipe *J*. The mixture of superheated steam, tar vapours and distillation gas is passed off through the tube *K*. A modified design of apparatus is also described in the specification.—*September* 29, 1954.

Launches and Trial Trips

DALILA, oil tanker; built by the Chantier et Ateliers de Saint Nazaire-Penhoet for the Compagnie Auxiliaire de Navigation; length overall 664ft 7in, length between perpendiculars 631ft, breadth moulded 86ft 9in, depth moulded 46ft 7in, draught loaded 32ft 1¾in, deadweight 32,850 tons; ten centreline and twelve wing cargo oil tanks; two 500kW turbine-driven alternators, one 100kW diesel-driven generator; trial speed 16·3 knots; one set of double reduction gear C.E.M.-Parsons turbines, normal power 13,750 s.h.p., maximum power 15,000 s.h.p., steam supplied at 640 lb per square inch and 860 deg. Fah. by two P.41 Penhoet water-tube boilers. Trial, September.

PHENIX, oil tanker; built by the Ateliers et Chantiers de la Loire for the Society Courtages et Transports and Delmas-Vieljeux; length between perpendiculars 557ft 9½in, breadth moulded 74ft 6in, depth moulded 40ft 8in, draught loaded 31ft 4in, displacement 28,700 tons, deadweight 21,500 tons; service speed 14 knots; Sulzer-Loire diesel engine, 8400 b.h.p. at 125 r.p.m. Trial, September.

ANGKOR, coastal tanker; built by the Chantiers Dubigem for the Shell Company, Ltd.; length overall 196ft 10in, length between perpendiculars 187ft, breadth moulded 36ft 1in, depth 12ft 10in, draught loaded 11ft, deadweight 950 tons, service speed 10·5 knots; two Sulzer diesel engines built by the Ateliers et Chantiers de la Loire, each 600 b.h.p. at 300 r.p.m. Trial, September.

Catalogues

PETBOW, Ltd., Sandwich, Kent.—Catalogue of power plant and equipment.

J. H. FENNER AND CO., Ltd., Marfleet, Hull.—Copy of the Pioneer oil seals catalogue.

W. E. SYKES, Ltd., Staines, Middlesex.—Illustrated brochure describing Sykes vertical gear generating machine, model U.4.

HERBERT WIDDOWSON AND SONS, Ltd., Canal Street Works, Nottingham.—Copy of the latest "Widdowson" machine tool catalogue.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2.—Booklet entitled "Research, Development, Achievement."

BABCOCK AND WILCOX, Ltd., Babcock House, Farringdon Street, London, E.C.4.—Publication number 1535/1, entitled "Babcock Steam."

LACRINOID PRODUCTS, Ltd., Gidea Park, Essex.—Brochure illustrating and describing "Vietum," a method of covering rods tubes and bars by shrinkage.

RENOLD CHAINS, Ltd., Renold House, Wythenshawe, Manchester.—Leaflet entitled "Four Reasons Why You Should Fit the Coventry Mark 5 Steel Chains and Wheels."

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Leaflet describing a 450-ton universal hydraulic press installed by the I.C.I. Metals Division.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., 82, York Way, King's Cross, London, N.1.—Further sections of the Westinghouse signal catalogue:—Part 5, Section 2C, M3 Point Machine; Part 8, Section 1P, D.C. Relay, Styles S2 and S4; Part 8, Sections 3C, 3F, 3G and 3R, A.C. Relays; Part 13, Section 1, Hump Yard Equipment.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Nov. 4th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Latest Developments in T.V. Cameras," H. McGhee, 7 p.m.——MERSEYSIDE SECTION: College of Technology, Byron Street, Liverpool, 3, "Radio Receiving Valve Manufacture," G. P. Thwaites, 7 p.m.——NORTH-WESTERN SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Electronic Servo Mechanisms," J. L. Russell, 7 p.m.

Wed., Nov. 10th.—N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "Stereophonic Sound," R. A. Bull, 6 p.m.

Thurs., Nov. 11th.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Edinburgh, "Nuclear Fission and Nuclear Fusion," N. Feather, 7 p.m.

CHEMICAL SOCIETY

Thurs., Nov. 4th.—Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7, "Open and Closed Sequences in Reaction Kinetics," J. A. Christiansen, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, Oct. 29th.—BIRMINGHAM CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Teaching Illuminating Engineering," 6.30 p.m.

Wed., Nov. 3rd.—EDINBURGH CENTRE: Manor Club, 12, Rothesay Place, Edinburgh, "The Design and Application of Flameproof Lighting Equipment," D. A. Strachan, 7 p.m.——NEWCASTLE CENTRE: Roadway House, 8, Oxford Street, Newcastle, Symposium, "Sports Lighting," presided over by W. Robinson, 6.15 p.m.

Thurs., Nov. 4th.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, "The Design and Application of Flameproof Lighting Equipment," D. A. Strachan, 7.30 p.m.——NOTTINGHAM CENTRE: E. Midlands Electricity Board, Smithy Row, Nottingham, "The Lighting of Shipyards," J. S. McCulloch, 6 p.m.

Tues., Nov. 9th.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Shop Lighting," R. L. C. Tate, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Oct. 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Films, "Oil in Industry," "Liquid Fuel in Industry," "Grease," "Project 074," followed by discussion, 7.30 p.m.

Tues., Nov. 2nd.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "The Science of Applied Chromatics," E. M. Barford, 7 p.m.

Wed., Nov. 3rd.—SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Steam Costs," E. C. Rogers, 7.30 p.m.——LEICESTER BRANCH: College of Art and Technology, The Newarkes, Leicester, "Process and Industrial Heating," J. C. Edwards, 6.30 p.m.

Thurs., Nov. 4th.—PETERBOROUGH BRANCH: Eastern Gas Boards' Demonstration Theatre, Church Street, Peterborough, "Metal Spraying," W. E. Ballard, 7.30 p.m.

Mon., Nov. 8th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Refrigeration Problems," G. S. R. Shaw, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 9th.—SLOUGH SECTION: Lecture Theatre, High-Duty Alloys, Ltd., Slough, Bucks, "Propeller Manufacture," J. M. Langham, 7.30 p.m.

INSTITUTE OF FUEL

Mon., Nov. 1st.—SCOTTISH SECTION: Royal Technical College, Glasgow, "The Constitution of Coal Tar," D. McNeil, 7 p.m.

Fri., Nov. 5th.—S. WALES SECTION: Y.M.C.A., Kingsway, Swansea, "Back-Pressure Regeneration," C. Ungoed, 6 p.m.

INSTITUTE OF INDUSTRIAL SUPERVISORS

Tues., Nov. 2nd.—LONDON CENTRAL SECTION: Waldorf Hotel, Aldwych, London, W.C.2, Joint Meeting with Institution of Works Managers, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, Oct. 29th.—MERSEYSIDE AND NORTH-WESTERN SECTION: Old Swan Technical College, Liverpool, "Marine Diesel Engines," A. G. Arnold, 7 p.m.

INSTITUTE OF METALS

Tues., Nov. 2nd.—OXFORD LOCAL SECTION: Cadena Café, Cornmarket Street, Oxford, "Ceramics," J. White, 7 p.m.

Thurs., Nov. 4th.—LONDON LOCAL SECTION: Royal School of Mines, South Kensington, London, S.W.7, "Trends in Metallurgy," A. G. Quarrell, 7 p.m.——BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Metallurgical Research in the Electrical Industries," Ivor Jenkins, 6.30 p.m.

INSTITUTE OF PETROLEUM

To-day, Oct. 29th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Conference on "Molecular Spectroscopy," organised by Spectroscopic Panel of the Hydrocarbon Research Group.

INSTITUTE OF PHYSICS

To-day, Oct. 29th.—47, Belgrave Square, London, S.W.1, Discussion Group led by W. G. Cook on "Jet Engines and Non-Destructive Testing," 6.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Nov. 1st.—SCOTTISH CENTRE: North British Station Hotel, Edinburgh, "Hydraulic Transmissions," J. Houghton, 7.30 p.m.

Tues., Nov. 2nd.—N.W. CENTRE: Victoria and Station Hotel, Preston, "Commercial Vehicle Electrical Equipment," C. T. Corney and A. V. Waters, 7.30 p.m.

Wed., Nov. 3rd.—EASTERN CENTRE: Swan Hotel, Bedford, "Clutch and Brake Linings," L. P. Godfrey, 7 p.m.

INSTITUTE OF WELDING

Tues., Nov. 9th.—LIVERPOOL AND DISTRICT BRANCH: Liverpool College of Technology, Byron Street, Liverpool, "Make Do and Mend Repairs," G. G. Musted, 7.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, Oct. 29th.—SCUNTHORPE BRANCH: Blue Bell Hotel, Scunthorpe, "The Design and Construction of the Handling and Treatment System for Liquid Radio-Active Wastes," W. L. Wilson, and "Operational Experiences with a Handling and Treatment System for Liquid Radio-Active Wastes," R. H. Burns, 6.30 p.m.

Tues., Nov. 2nd.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, Presidential Address by D. M. Watson, 5.30 p.m.

Mon., Nov. 8th.—LEEDS BRANCH: General Lecture Theatre, Leeds, "Owen Falls, Uganda, Hydro-Electric Development," Sir Charles Westlake, T. A. L. Paton and R. W. Mountain, 7 p.m.

Tues., Nov. 9th.—AIRPORT MEETING: Great George Street, Westminster, London, S.W.1, "Some Considerations of Airfield Pavement Design," J. A. Skinner and F. R. Martin, 5.30 p.m.

Wed., Nov. 10th.—HULL BRANCH: Electricity Showrooms, Lecture Theatre, Ferensway, Hull, "Construction of Queen Elizabeth II Dock," D. C. Milne, 6.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Nov. 1st.—LONDON STUDENTS' SECTION: Savoy Place, London, W.C.2, "Pumped Storage for Peak Load Power Supplies," C. D. Gardiner, 7 p.m.——S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Possibilities of a Cross-Channel Power Link between the British and French Supply Systems," D. P. Sayers, M. Laborde and F. J. Lane, 6 p.m.

Tues., Nov. 2nd.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, Discussion on "Boreholes: Instrumentation for Measurements at Depth," P. Threadgold, 5.30 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies on 2nd June, 1953," W. S. Proctor, M. J. L. Pulling and F. Williams, 6.30 p.m.——S.E. SCOTLAND SUB-CENTRE, CENTRE MEETING: Carlton Hotel, North Bridge, Edinburgh, "The Possibilities of a Cross-Channel Power Link," D. P. Sayers, M. E. Laborde, F. J. Lane, 7 p.m.

Wed., Nov. 3rd.—S.W. SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Possibilities of a Cross-Channel Power Link," D. P. Sayers, M. Laborde and F. J. Lane, 7 p.m.

Thurs., Nov. 4th.—ORDINARY MEETING: Savoy Place, London, W.C.2, "A Transatlantic Telephone Cable," M. J. Kelly, Sir Gordon Radley, G. W. Gilman and R. J. Halsey, 5.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Nov. 1st.—NORTH-EAST BRANCH: Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, "Research and the Designer," A. F. B. Young, 7.15 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Nov. 2nd.—COVENTRY BRANCH: Technical College, Coventry, "The Application of Gas Turbines to Road Transport," P. A. Phillips, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 2nd.—39, Elmbank Crescent, Glasgow, "Resistance and Propulsion of Single-Screw Coasters, Part II, L/B-6," J. Dawson, 7.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Nov. 17th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "A Modern Hydraulic Drive for Locomotives," R. H. Fett, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Oct. 29th.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Parsons Memorial Lecture, "Factors Influencing the Continuing Development of the Gas Turbine," F. Dollin, 5.30 p.m.

Mon., Nov. 1st.—N.E. BRANCH: Neville Hall, Newcastle upon Tyne, Parsons Memorial Lecture, F. Dollin, 6 p.m.

Tues., Nov. 2nd.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion, "The Place of the Gas Turbine cum Two-Stroke Engine/Gas Generator Unit in the Future Pattern of the Oil Engine Industry," 6.45 p.m.——SOUTHERN GRADUATES' SECTION: The College, Bournemouth, "The Hydraulic Control of Presses," F. H. Towler, 7.30 p.m.

Wed., Nov. 3rd.—S. WALES GRADUATES' SECTION: Y.M.C.A., Kingsway, Swansea, "High Speed Food Can Manufacturing," D. D. Jenkins, 7 p.m.

Thurs., Nov. 4th.—N.E. GRADUATE SECTION: Head Wrightson's Ironworks, Stockton-on-Tees, "St. Clements' Bridge, Aberdeen," W. E. Marshall, 7 p.m.

Fri., Nov. 5th.—INTERNAL COMBUSTION ENGINE GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "An Experimental Coal-burning Gas Turbine," L. D. Mordell, 5.30 p.m.

Mon., Nov. 8th.—SCOTTISH GRADUATES' SECTION: Royal Technical College, Glasgow, Film Evening, 7.30 p.m.

Wed., Nov. 17th.—SOUTHERN BRANCH: Brighton Technical College, Brighton, Sussex, "The Future of the C.I. Engine in Small Road Vehicles," J. H. Pitchford, 7 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Nov. 9th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Future Demands for Telephone Service: Possible Trends and Reactions," J. M. Norman, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Oct. 30th.—LINCOLN SECTION: The Ruston Club, Unity Square, Lincoln, "How the Production Engineer can be Helped by the Metallurgist," J. D. Jevons, 7.30 p.m.

Tues., Nov. 2nd.—HALIFAX SECTION: White Swan Hotel, Halifax, "The Shell Moulding Process," D. N. Buttrey, 7.15 p.m.——NOTTINGHAM SECTION: Welbeck Hotel, Milton Street, Nottingham, "Costing and Measurement of Productivity," W. Coutts Donald, 7 p.m.

Wed., Nov. 3rd.—PETERBOROUGH SECTION: Campbell Hotel, Bridge Street, Peterborough, "Motion and Time Study," Anne G. Shaw, 7.30 p.m.

Thurs., Nov. 4th.—GLOUCESTER AND DISTRICT SECTION: Bell Hotel, Gloucester, "Productivity," F. L. Daniels, 7.15 p.m.——READING SECTION: Petters, Ltd., Causeway Works, Staines, Middx., "Recent Developments in Work Study," N. A. Dudley, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Nov. 2nd.—NORTHERN IRELAND BRANCH: Grand Central Hotel, Belfast, Annual Dinner and Social Function, 6.30 p.m.——NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, "Further Studies of Load Distribution in Bridge Decks," G. Little, 6.30 p.m.——WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, "Llandarcy Refining Expansion Engineering," F. V. M. Bell, 6.30 p.m.

Thurs., Nov. 4th.—MIDLAND COUNTIES BRANCH: Public Library, Stafford, "Examples of Site Exploration," E. Morton, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Nov. 1st.—MERSEYSIDE SECTION: Committee Room, Liverpool Corporation Passenger Transport Office, 24, Hatton Garden, Liverpool, "Latex Foam Rubber," G. J. Bibby, 7 p.m.

IRON AND STEEL INSTITUTE

Wed. and Thurs., Nov. 17th and 18th.—4, Grosvenor Gardens, London, S.W.1, Autumn General Meeting.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 29th.—INFORMAL MEETING: Pepys House, 14, Rochester Row, London, S.W.1, "Some Notes on the Static Compressive Strength of Wool Felt, with Reference to the Isolation of Shock," followed by "Some Notes on the Dynamic Characteristics of Wool Felt," R. J. Herbert, 7 p.m.

Wed., Nov. 3rd.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Modern Tendency of Railway Signalling Practice," W. J. Sadler, 7 p.m.

Fri., Nov. 5th.—Pepys House, 14, Rochester Row, London, S.W.1, Film Evening, E. A. Applebee, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Nov. 18th.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Fracture of Metals," C. E. Phillips, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Oct. 29th.—Engineers' Club, Albert Square, Manchester, "Testing Lubricants for the Prevention or Promotion of Wear," T. B. Lane, 6.45 p.m.

Fri., Nov. 12th.—Engineers' Club, Albert Square, Manchester, 2, "A Brief Survey of the Early History of Woolwich Arsenal," O. F. G. Hogg, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Oct. 29th.—Mining Institute, Newcastle upon Tyne "Ship Structural Members: Part VI," J. McCullum, 6.15 p.m.

Fri., Nov. 12th.—Mining Institute, Newcastle upon Tyne "Instrumentation in Engineering Research with Particular Reference to Marine Turbine Machinery," B. J. Terrell, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 2nd.—SECTION LECTURE: 4, Hamilton Place, London, W.1, "Design of Small Jet Engines," H. S. Rainbow, 7 p.m.

ROYAL SOCIETY OF ARTS

Wed., Nov. 3rd.—John Adam Street, Adelphi, London, W.C.2, Inaugural Address, "Looking Ahead," E. Munro Runtz, 2.30 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Tues., Nov. 16th.—B.I.S.R.A., Hoyle Street, Sheffield, "Specifications: Friends or Foes?" S. Barraclough, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Nov. 9th.—Geological Society, Burlington House, London, W.1, "The Decoloration of Sugar Liquor by Solid Absorbents," H. C. S. de Whalley, 5.30 p.m.

Thurs., Nov. 18th.—Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, "The Constitution and Structure of Coal Tar Pitch," L. J. Wood, 6 p.m.

WOMEN'S ENGINEERING SOCIETY

Thurs., Nov. 4th.—MANCHESTER BRANCH: Visit to the British Oxygen Company, Ltd., 6.45 p.m.